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РЕЗЮМЕ

ДВЕ РАЗНОВИДНОСТИ ЛИПИДА В МИОЗИНЕ. АНИЗОТРОПИЯ ЛИПИДНОГО КЕЛАТА И ВЗАИМООТНОШЕНИЕ КОМПЛЕКСОВ С ИОНАМИ Mg^{2+} и Ca^{2+} И ОСНОВНЫХ АМИНОКИСЛОТ

Ш. ФАЗЭКАШ, И. ОВАРИ, В. СЕКЕШШИ-ХЕРМАНН, Э.ТАТРАИ

В настоящей работе показано, что из миозина с помощью смеси хлороформа и метанола можно получить смешанную фосфо-липидную фракцию (L_1), а также фракцию, изолируемую ацетоном (L_2). Главным компонентом у L_1 является лецитин, а у L_2 почти исключительно, фосфатидил этаноламин. У последнего 60% всех жирных кислот является ненасыщенной кислотой и намного более самоокислительной, чем фракция L_1. Оба липида являются нативными и на поляризирующих снимках образуют миэлиновые рисунки; под влиянием основных аминных кислот получаются интеракционные, а под влиянием двухвалентных металлических ионов кристаллы типа келата, или образуются агрегаты, анизотропия которых варьирует. Интеракционные и келатные кристаллы липидов, далее присутствие келатной модели миозина доказывает, что липид является интегральной частью молекулы миозина и специфические липиды участвуют в поддержании конструкции и энзимной активности белков. Липиды и изменённые условия белка через металлические ионы модифицируют некоторые фазы энзимной деятельности.

ИЗУЧЕНИЕ НЕДОСТАТКА МИКРОЭЛЕМЕНТОВ НА ПАСТБИЩАХ ВЕНГЕРСКОЙ ПУСТЫ ХОРТОБАДЬ

А. САЛАИ, З. ШАМШОНИ, З. ШИРОКИ, И. ЭЛ-ХИАТЕМИ

Представляется краткий отчет, составленный на основе обширного микроаналитического исследования содержания микроэлементов у образцов фуражных растений, собранных на алкалических солончаковых почвах венгерской пусты Хортобадь. Фуражные растения по средним показателям везде характеризируются недостатком Zn, Cu и Fe. Недостаток Mn незначительный, за исключением некоторых мест. Растения в достаточной мере снабжены B и Mo; почвы являются богатыми всеми микроэлементами, однако алкалиды иммобилизуют катионы Fe, Mn, Zn и Cu и таким образом они становятся трудно доступными для растений. B и Mo для растений доступны, потому что при данных условиях pH они находятся в форме анионов. Проблемы разведения овец, наблюдающиеся в течение долгих лет, объясняются недостатком микроэлементов в корме на этих пастбищах.

ВЛИЯНИЕ УРОВНЯ И ИСТОЧНИКА КОРМОВОГО ПРОТЕИНА НА НЕКОТОРЫЕ СОСТАВНЫЕ ЭЛЕМЕНТЫ КРОВИ У ГИБРИДНЫХ ЯГНЯТ

Ш. МАХМОУД, Б. ЮХАС, Б. СЕГЕДИ

В экспериментах, проведенных с гибридными ягнятами Suffolk x Венгерское мерино, исследовали влияние уровня и источника кормового протеина на некоторые составные элементы крови. Результаты показали, что с увеличением азота в крови не увеличивается достоверно ни общий протеин, ни общее количество аминных кислот. В то же время, концентрация карбамида в плазме достоверно повышалась. Несмотря на то, что кормовой карбамид повысил его уровень в плазме, однако, вследствие этого, общее количество протеинов и аминных кислот в плазме крови не изменилось.

БИОПОЛИМЕРНЫЕ МЕТАЛЛ-СОДЕРЖАЩИЕ КОМПЛЕКСНЫЕ СИСТЕМЫ. II. ФИЗИЧЕСКИЕ СВОЙСТВА ГУМИДНЫХ ВЕЩЕСТВ И ИХ МЕТАЛЛ-СОДЕРЖАЩИХ КОМПЛЕКСОВ

Ш. ШИПОШ, Э. ШИПОШ, И. ДЭКАНЬ, А.ДЕЭР, Й. МЕИСЕЛ, Б. ЛАКАТОШ

Путём аналитического ультрацентрифугирования и метода гель-фильтрации был определён молекулярный вес (mwt) и распределение молекулярного веса гумидных веществ и металл-содержащих гуматов различного происхождения, как функция pH и электролитной концентрации. I. Средний молекулярный вес (mwt), размер и форма частичек подтверждают наличие молекулярных агрегатов в водном растворе. Эти агрегаты быстро распадают в условиях повышенного pH. 2. Изменение mwt гумидных кислот различного происхождения и возраста, и их поведение как функция pH, подтверждает тот факт, что в дополнение к возрасту образца все условия превалирующие во время изменения комплекса нужно учитывать при разъяснении коллоидной структуры. 3. Трёхвалентные металлические ионы увеличивают молекулярный вес гумидных кислот почти экспоненциально, в то же время двухвалентные катионы вызывают только линеарное увеличение. Влиянием ионов магния можно пренебречь даже при высоких концентрациах элекролитов. 4. Полидисперсия исследовалась с помощью декстран-гель-фильтрации и определено распределение mwt.

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TWO VARIATIONS OF LIPID IN MYOSIN. ANISOTROPY OF LIPID CHELATE AND INTERACTION COMPLEXES WITH Mg^{2+} AND Ca^{2+} IONS AND BASIC AMINO ACIDS

By

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The present paper shows the possibility of using a mixture of chloroform and methanol to obtain a mixed phospholipid fraction (L_1) and an acetone extractable fraction (L_2) from KCl myosin. The main, P-contain component of L_1 is lecithin, while L_2 consists almost entirely of phosphatidyl ethanolamine. More than 60% of the fatty acids in the latter are unsaturated and can be autooxidised much more completely than in L_1. Both lipids are native, and develop myelin figures in polarization exposures: these take the form of interaction crystals or aggregates under the influence of basic amino acids, and of chelate type crystals or aggregates of different anisotropy when exposed to metal ions. The interaction and chelate crystals of lipids, as well as the existence of the chelate model of myosin indicate that lipid is an integral part of the myosin molecule and the specific lipids take part in maintaining the structure and enzyme activity of protein. Through the metal ions, on the other hand, the changed relation of lipids and protein has a modifying effect on the individual phases of the enzyme activity.

Introduction

According to LYNN (1965) myosin has a 4% lipid content which cannot be removed, but only reduced with lipid solvents. Our experiments showed a much higher lipid content even in chromatographically purified myosin. In fact, a considerable amount of lipid is removed in each phase of purification, yet the purified myosin is obtained with a definite lipid content. When extracted with a mixture of Chl : MeOH the lipid content of myosin can only be substantially reduced after a long process of treatment. Chromatographic purification, however, resulted in several myosin fractions with different lipid contents and ATP-ase activities. The lipid of myosin is mainly lecithin and phosphatidyl ethanolamine. In the open air the isolated lipid quickly peroxidizes and its Rf-value, on a TLC plate covered with Silica G, undergoes a change. The fluorescence maximum of peroxidized lipids shifts to higher wavelengths and always breaks up into several maxima showing the heterogeneity of these lipids (FAZEKAS *et al.* 1973).

Myosin delipidated with the Chl : MeOH mixture is not totally free of lipids. So we set ourselves the objective of isolating this closely bound lipid and deciding whether the lipids of myosin had any organizing action. Since the lipids originate from the myosin of a single muscle *(m. long. dorsi)*, we are justified in thinking of these lipids as displaying an organizing activity between the molecules of myosin and its subcomponents, or within the peptide chain although we noticed earlier that the chromatographically removable lipid had no significant effect on the ATP-ase activity of myosin, on the contrary, the reduced lipid content led to a slight increase in the enzyme activity. However, the lipid solvent treatment, besides decreasing the lipid content of myosin, results in substantial structural changes: the myosin aggregates and its ATP-ase activity ceases. Consequently we decided to examine the interaction tendency of lipids and their capacity to form chelate complexes, and to correlate them with the lipid content of myosin.

Material and Method

Myosin was prepared from a single muscle *(m. long. dorsi)* of rabbit, as earlier described in detail (FAZEKAS *et al.* 1974). The reason for preparing the myosin from a single kind of muscle was to avoid disturbances caused by the "chromatographic heterogeneity of myosin".

We extracted the ultracentrifuged myosin solution (20—40 mg/ml) with 10 volumes of Chl : MeOH 2 : 1 reaction mixture, taking care to add first the methanol and then the chloroform to the myosin. Extraction was repeated three times. The aqueous phase was removed and the lipid fractions combined (fraction L_1). All phases of lipid isolation were carried out at 0°C.

The protein-containing phase was mixed with 10 ml distilled water, then with 90 ml acetone, and the mixture was left to stand in a refrigerator. Extraction was repeated twice with a 90% aqueous solution of acetone. The acetone fractions (L_2) were combined and used fresh for the preparation of complexes. The residue was used for preparative purposes. In order to prepare lipid complexes the average molecular weight of the lipids was taken as 760 g. The lipids were used to form the interaction complexes of amino acids and to develop the chelate complexes of Mg^{2+} and Ca^{2+}. The mol/mol ratio of the components was 1 : 10. We used amino acids as free bases, cysteine in the form of hydrochloride and the metal ions as chloride salts. The molecular weight of myosin was taken as $5 \cdot 10^5$, and, for the formation of interaction products, the joint amount of basic amino acids (Arg, Lys) and of cysteine, serine and histidine contained in the myosin (415, 208, 42, 228 and 79, according to the data of amino acid analysis performed by WEEDS—HARTLEY 1968) was taken as roughly 1000. The ratio of metal ions to myosin in the myosin chelate complex-forming reaction mixture was adjusted accordingly to 1 : 800 (mol/mol).

We used a low concentration solution of myosin (0.1 mg/ml in 0.5 M KCl) in producing the chelates of metal ions. The pH of the myosin, still at a high concentration, was adjusted with KOH to 7.8—8.0; consequently in the microscope preparation only crystals of KCl appeared as by-products.

To develop these complexes we mixed 0.05 ml of solution from each of the reaction partners on concave slides and added the same volume of acetone at room temperature. The development of the freshly formed crystals was then observed, as were the changes which occurred in them over nearly two months, without using a cover slide.

The morphological appearance and anisotropy of the complexes were studied with a Zeiss Ergaval microscope furnished with a polarization piece (with a No. 4 compensator slide, in a diagonal position). The microphotographs were taken using a Zeiss planapochromat 16× objective and a Zeiss 3.2× ocular, at a standard camera length with automatic exposure, as described earlier (ÓVÁRY *et al.* 1977).

Results

The lipid fraction (L_1) isolated from myosin with a 2 : 1 mixtures of Chl : MeOH is composed of several components, though more than 60% of it is made up of lecithin, which turns yellow in the open air at a slower rate than fraction L_2.

On the polarization microphotographs the crystalline forms have never been observed, only coarse aggregates whose anisotropy increases in time with the advancing process of auto-oxidation (Fig. 2a). The coarse aggregates are

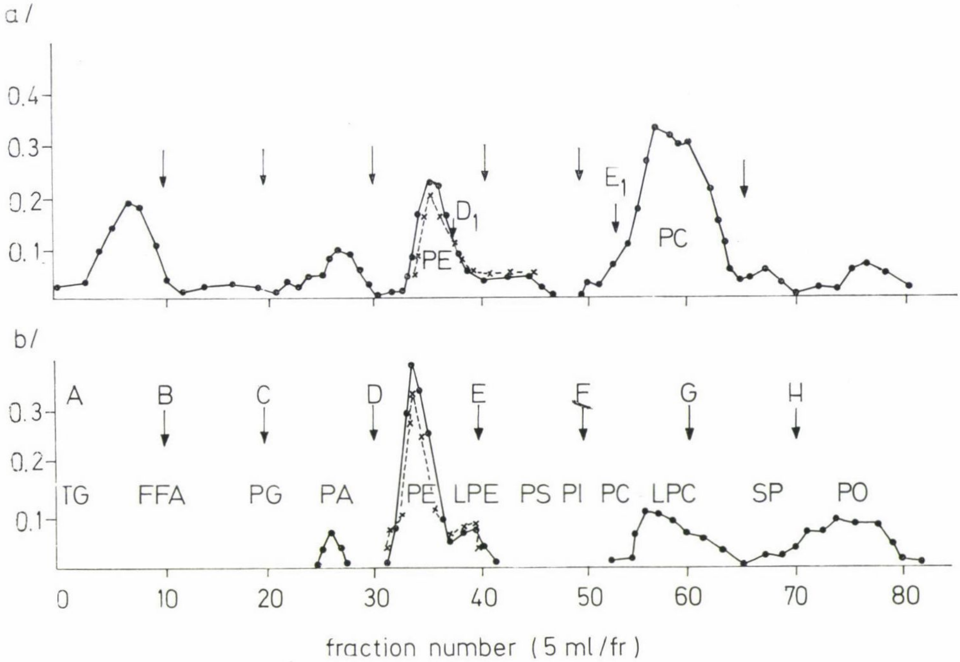

Fig. 1. Chromatography of L_1 and L_2 lipid fractions on silica gel column. Effluents are: a) Chl : Meth. extracted lipid; b) acetone extracted lipid; •—• Pi constant; x—x ninhydrin r. (Chl : Meth. A = 100 : 0; B = 99 : 1; C = 96 : 4; C_1 = 90 : 10; D = 7 : 1; D_1 = 3 : 1; E = 2 : 1; E_1 = 1.5 : 1; F = 1 : 2; G = 1 : 4; H = 0 : 100)

dispersed and transformed into microcrystals of ATP-L_1 interaction complexes of intensive anisotropy by the ATP (b). The Mg-L_1 chelate microcrystals, which are highly anisotropic with Mg^{2+} ions but heterogeneous, are organized, as their aggregates (c), and they appear in the field of view of the microscope within a few minutes. Ca-L_1 complexes formed with Ca^{2+} ions (d) show an even more intensive anisotropy. Both chelate complexes display a crystalline structure when photographed in their native form.

We tried to produce interaction crystals of lipid with almost amino acid, but only the basic amino acids and the sulphur-containing cisteine showed

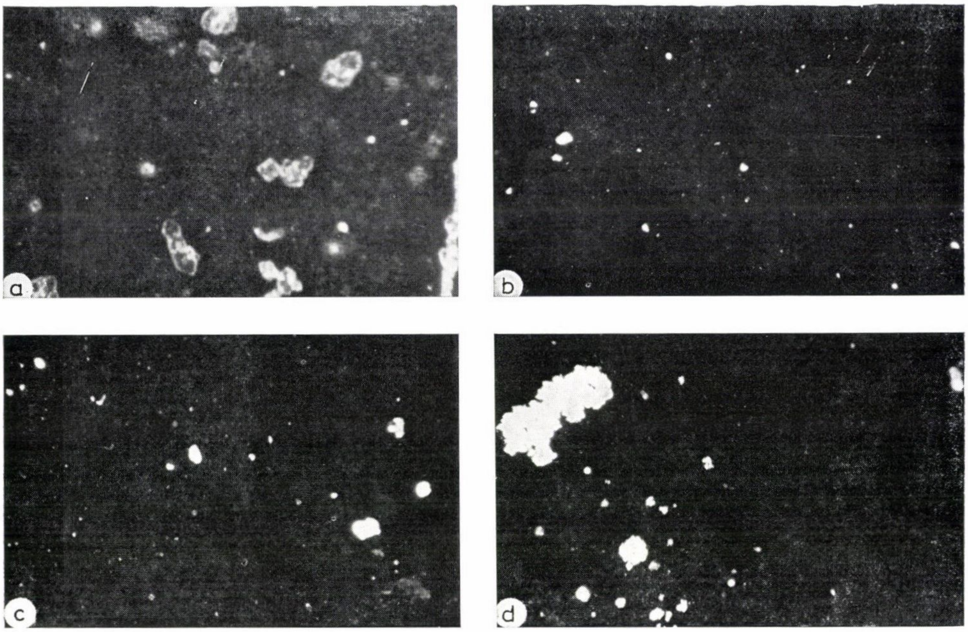

Fig. 2. Heterogeneous myelin figures of L_1 fraction (a), anisotropic interaction microcrystals of ATP-L_1 (b), heterogeneous Mg-L_1 chelate crystals (c), rough aggregates of Ca-L_1 chelates (d)

a characteristic interaction with lipids (Fig. 3). The crystals of the Arg-L_1 interaction complex are needles which tend to aggregate (a_1), or long needle-shaped crystals (a_2), or, in the case of an adequate concentration, crystals aggregated from solitary needles into bundles (a_3).

Lysine organizes the lipid of myosin-L_1 into highly anisotropic Lys-L_1 microcrystals. These crystals again are characterized by a tendency to aggregate. In the case of an adequate concentration the chelate appears in the form of a compact rosette (b).

The organizing ability of cysteine, which contains an SH-group, is very remarkable, since the anisotropic fragments, consisting of short segments, are arranged in a fingerprint pattern (Fig. 4a_1). The anisotropy of Cys-L_1 complexes becomes perceptibly stronger after several weeks (a_2). Serine exerts a dispersing effect on this lipid fraction. In the reaction mixture, at the edges of the microscopic field of view, the tiny anisotropic Ser-L_1 interaction crystals quickly appear (b_1), and the anisotropy of the crystals increases parallel to the aging of the preparation.

Histidine produces its effect at a slower rate. The arrangement of the amorphous material under the influence of histidine can be easily followed in the visual field of the microscope. The sausage-like forms, which are hardly anisotropic at the beginning (c_1), are transformed into highly anisotropic compact interaction complexes or even aggregates (c_2).

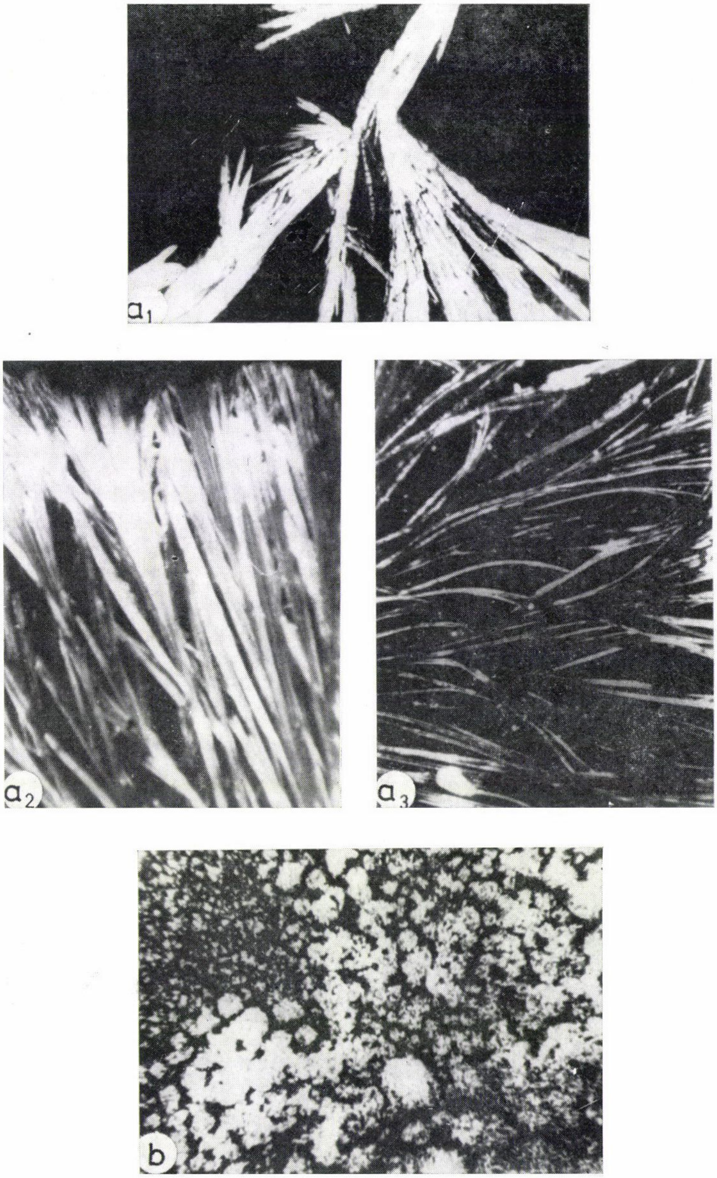

Fig. 3. Needle-like aggregates (a_1), solitary needles (a_2), and sheaf-like aggregates (a_3) of Arg-L_1 interaction crystals. Development of compact rosette-like aggregates of Lys-L_1 crystals (b)

Another lipid fraction (L_2) can also be removed, not only from myosins extracted with a mixture of Chl : MeOH, but from the heavy chain after the removal of the light chains. The L_2 is removed by means of 90% aqueous acetone extraction. When separated on a silica gel layer with the TLC method it appears mostly alone as phosphatidylecholine and, in a smaller quantity, in the place of lysophosphatidyl derivatives (Fig. 5). This lipid fraction autooxidizes more rapidly than L_1, and when concentrated transforms into a brown resinous mass.

The fresh acetone-lipid fraction (L_2) is highly water soluble and present in significant the di- and polyunsaturated bound fatty acids. Crystalline forms could not be obtained on native and polarization exposures, only rough aggre-

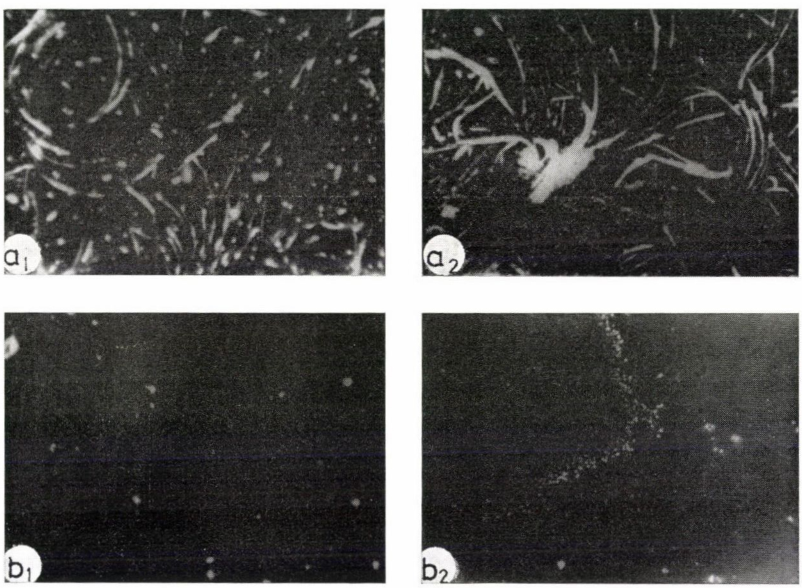

Fig. 4. Fingerprint-like aggregates of Cys-L_1 during crystal formation (a_1), and after their development (a_2). Appearance of microcrystals of Ser-L_1 at the edge of the preparation (b_1) and the fully developed microcrystals (b_2). His-L_1 interaction aggregate in the course of development (c_1) and the fully formed anisotropic aggregates (c_2)

gates or finely dispersed globuli; pseudostructures formed of tiny drops resembling pine branches were only found on native photographs (Fig. 6a).

With ATP the twin-thread lattice-work structure of the lipids is seen (b). On close examination the twin-threads turn out to be pseudo-threads running parallel, because the threads were organized into larger units from the transversal needles of the ATP-L_2 crystals.

Large aggregates of Mg-L_2 chelate crystals, formed with Mg^{2+} ions, show an extremely high anisotropy (c), while the heterogeneous microscrystalline chelates formed with Ca^{2+} ions show a lower degree of anisotropy (d).

The interaction complexes of L_2-lipid formed with basic amino acids are shown in Fig. 7. The highly anisotropic interaction complexes of arginine, consisting of needle crystals (a_1) with a characteristic structure form aggregates with structures very similar to that of the Arg-L_1 complex (Fig. 7a_1). The development of needles and aggregates is continuous; their formation is clearly shown by (a_2).

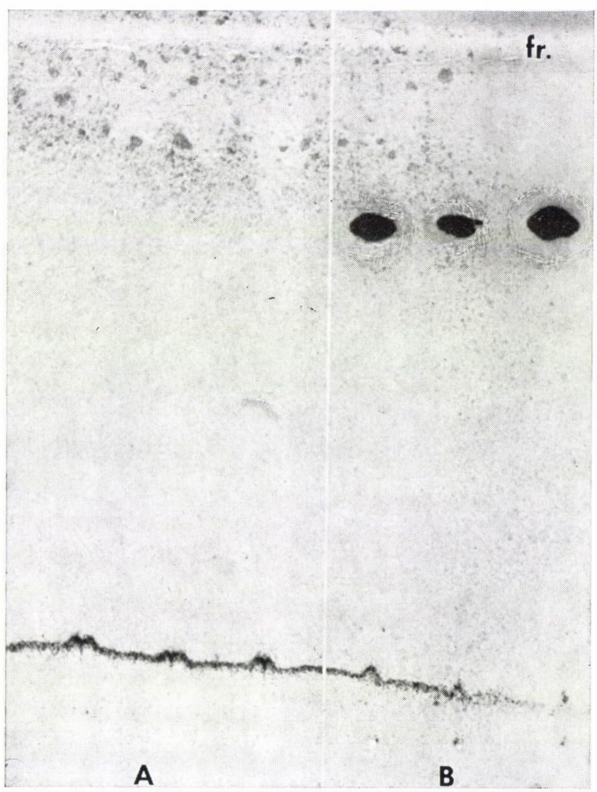

Fig. 5. Chromatography of L_2 on silica gel plate. (A) L_2-lipid, (B) autooxidised L_2-lipid scattered on chromatogram. Solvent system Chl : MeOH : water (65 : 25 : 4, v/v/v). Detected by HANES—ISHERWOOD (1949)

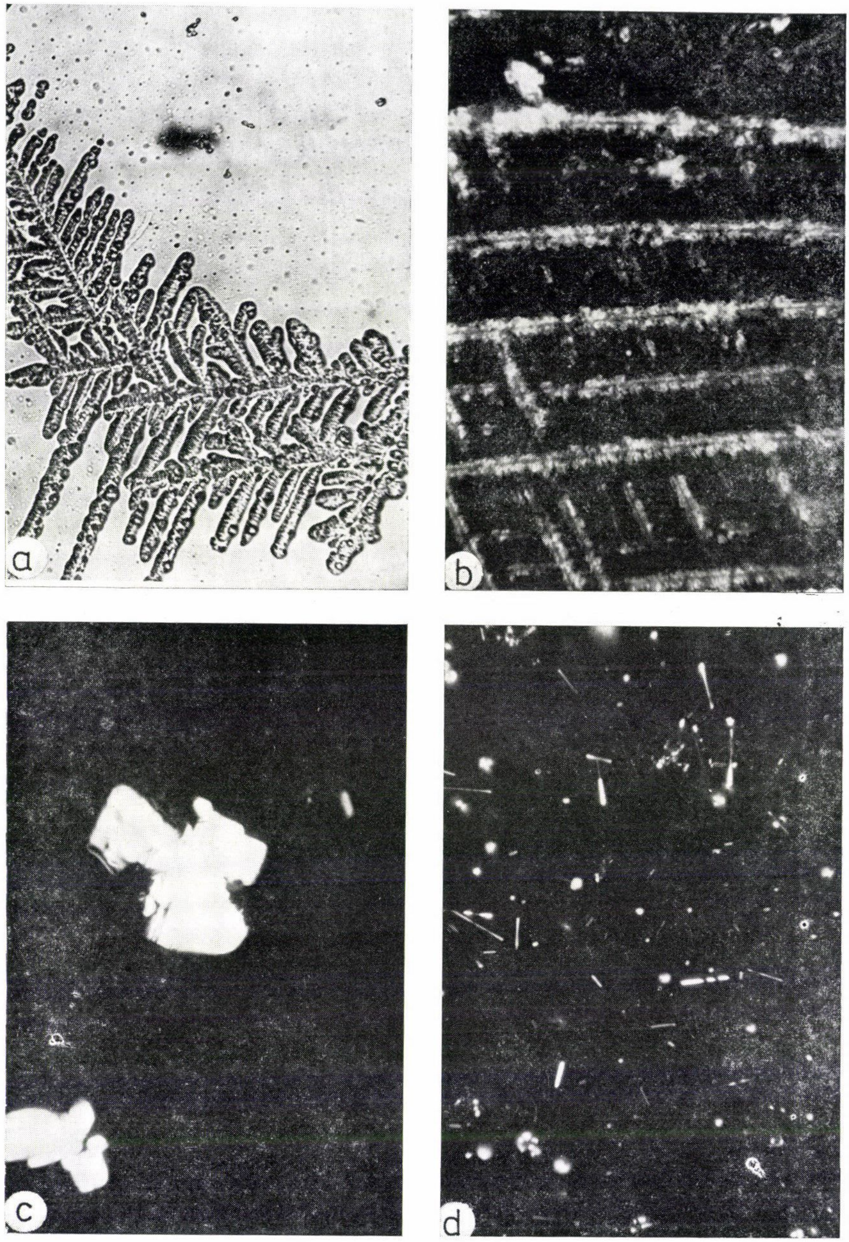

Fig. 6. Amorphous figures of L_2 fraction (a), double pseudothread-like lattice-work of ATP L_2 interaction chelate (b), being formed from transversal short needles. Strongly anisotropic Mg-L_2 crystal aggregates (c), and heterogeneous Ca-L_2 microcrystals (d)

From the L_2-lipid, lysine organizes a characteristic, anisotropic pseudo-needle structure consisting of tiny segments (b_1), which are much better visible on the native photo (b_2), since it can be seen here that structures resembling mosses (Bryophyta) grow out from some of the highly anisotropic aggregates.

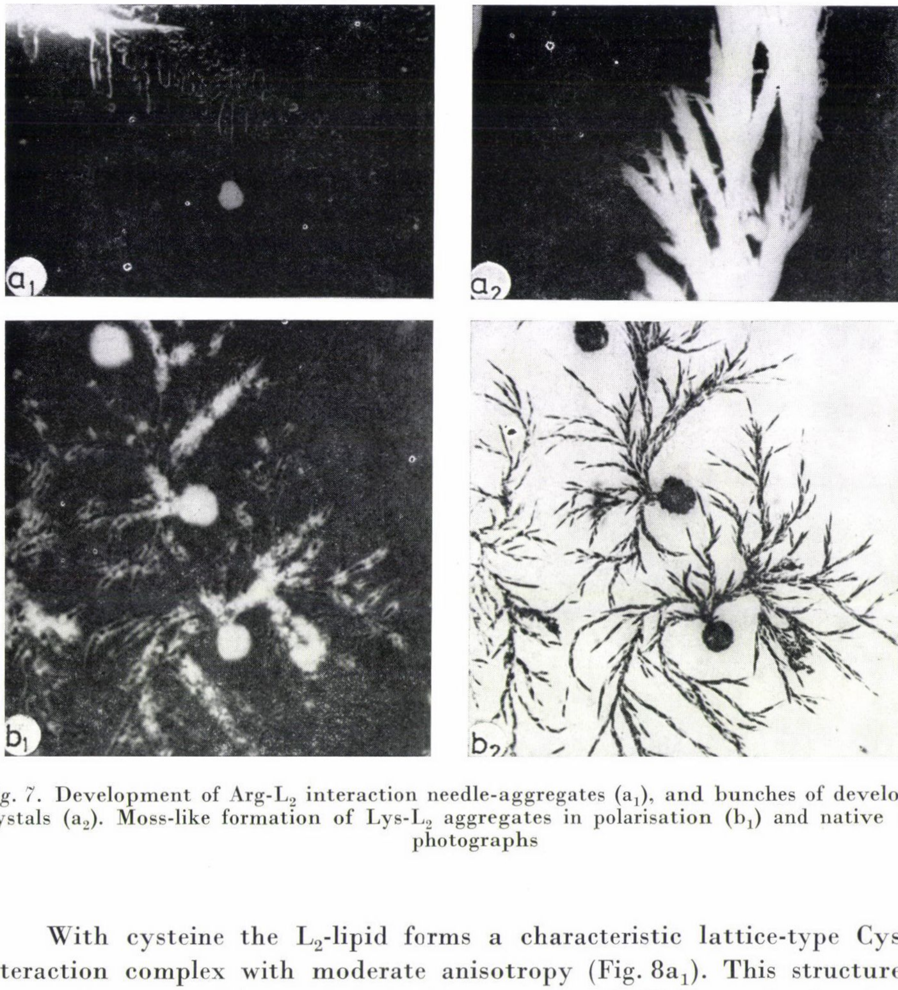

Fig. 7. Development of Arg-L_2 interaction needle-aggregates (a_1), and bunches of developed crystals (a_2). Moss-like formation of Lys-L_2 aggregates in polarisation (b_1) and native (b_2) photographs

With cysteine the L_2-lipid forms a characteristic lattice-type Cys-L_2 interaction complex with moderate anisotropy (Fig. 8a_1). This structure is a stable formation, the morphological appearance of which remained unchanged for 2 months, except that its anisotropy increased (a_2).

Serine disorganizes the L_2-lipid into tiny, characteristic, heterogeneous, spheric or shell-shaped structures. It is impossible to judge the contents of these structures from their shape alone, since some of them are empty, while others seem to be filled (b). The spherical structures are remarkable for their membrane-like anisotropy, which changes in patches.

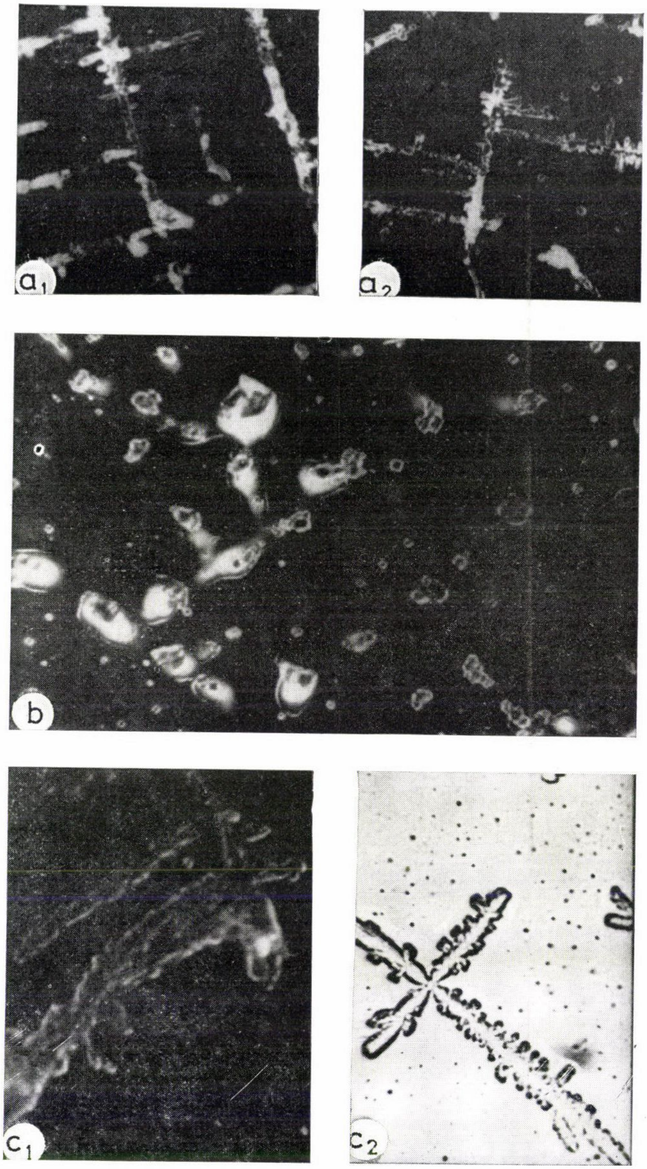

Fig. 8. Anisotropic lattice-work of Cys-L_2 crystals, immediately after appearance (a_1), and a week later (a_2). Myelin, and shell-like forms of Ser-L_2 interaction aggregates (b). Amorphous pseudostructures due to the effect of His. Polarisation (c_1) and native (c_2) photographs of the His-L_2 structure

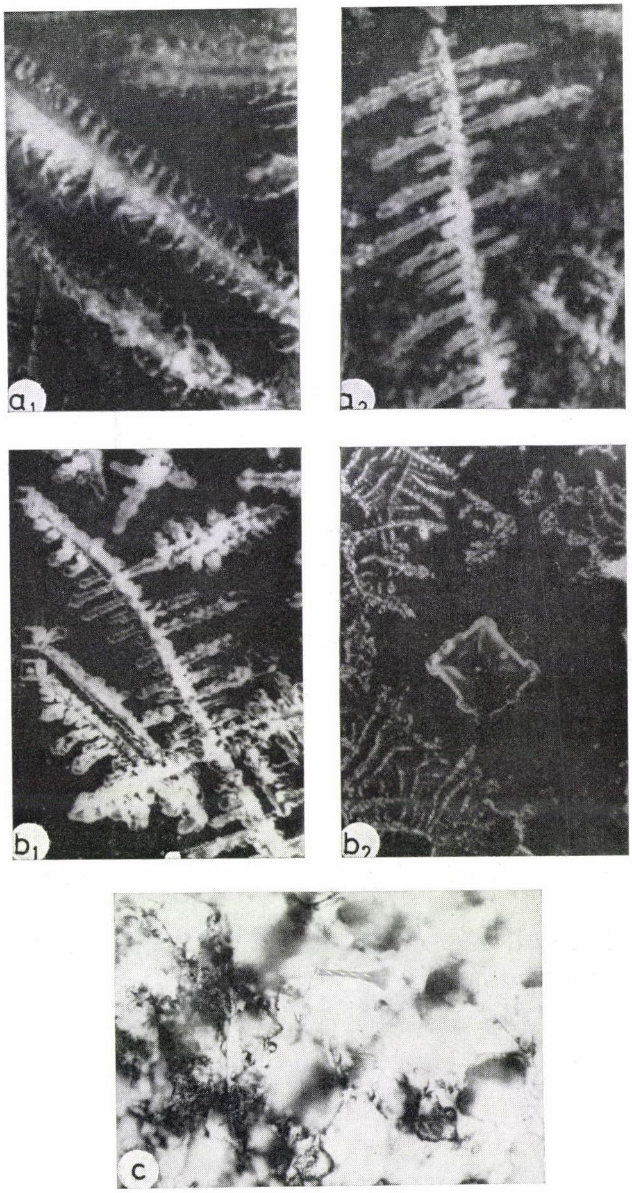

Fig. 9. Appearance of giant myosin aggregates (a_1) and pine branch-like figures (a_2) due to the effect of Mg^{2++} ions. Pine branch aggregates of Ca-Myosin chelate. Rough (b_1) and fine structure (b_2) with secondary branches. Rough amorphous aggregate of myosin with Cu^{2+} ions (c)

Histidine apparently has no organizing effect on L_2. The His-L_2 mixture appears in the visual field of the microscope partly as a few anisotropic microcrystals, and mostly as an amorphous mass (c_1). The native photo shows, however, that the amorphous mass has, in fact, an inner structure consisting of scattered microcrystals or tiny spheres (c_2), where the peripheral spheres seem to be black and the inner ones white.

The isolated lipids originate from the myosin, while the interacting amino acids are the normal components of the peptide chain of myosin. This raises the question of whether the myosin molecules show any characteristic structure with the divalent metal ions. In order to decide the question we tried to develop organized aggregate structures of myosin in the manner described in the methodological part of the paper, i.e. from a low concentration myosin solution. Without divalent metal ions myosin does not develop really organized structures; only amorphous aggregates and KCl crystals are seen in the visual field of the microscope. Under the influence of Mg^{2+} ions, on the other hand, giant chelates of long, undulating, lanceolate Mg-Myosin develop (Fig. 9a_1), to the folds of which many smaller aggregates may attach themselves. In the protein deficient zone of the microscopic field of vision thinner but more anisotropic branching chelate aggregates are organized (a_2). The formation is reminiscent of a pine branch.

The structure of the Ca-Myosin chelate formed under the influence of Ca^{2+} ions is much stronger than that of the Mg-chelate. At the end of the lateral branches the attachment of KCl crystals can be detected. In the marginal zone, which is poorer in protein, the formation is of a finer structure, like pine branches, while in many places the further structure of the branches appears to be composed of anisotropic spheres arranged parallel to each other (b_2).

It should be noted that other divalent metal ions do not develope organized aggregates; e.g. under the influence of Cu^{2+} ions giant aggregates of amorphous structure appear in the visual field of the microscope (c).

Discussion

The effect of divalent metals on lipids and on cells containing large quantities of lipid was reported recently by SAGGERSON *et al.* (1976). Cumulative double-bound fatty acids and lipids containing unsaturated fatty acids quench the fluorescence of proteins and free tryptophane, or reduce it to a minimum by forming interaction complexes with them (SKLAR *et al.* 1975).

Lipids, and especially phospholipids, are the normal structural components of many proteins. Cytochrome oxidase, for example, can be produced with a particularly high lipid content (47 mol phospholipid, i.e. 0.49 mg lipid/mg protein), and this quantity is necessary to maintain the structure and function of the enzyme. Part of the lipid content (0.17 mg/mg protein) is bound to the enzyme very tightly, in an immobilized state (JOST *et al.* 1973). According to WARREN *et al.* (1974) some 30 molecules of lipid are required to maintain the Ca^{2+}-ATP-ase enzyme activity of the sarcoplasmic reticulum. If the lipid content of the enzyme decreases the activity is irreversibly lost. The lipid is bound in a rigid immobilized state to the protein (NAKAMURA—OHNOSHI 1975). The linkage of rigid immobile lipids has also been demonstrated in the mitochondrial ATP-ase enzyme BERTOLI *et al.* 1976).

There is also a high lipid content in the myosin of the striated skeletal muscles of rabbits, much higher than that reported by LYNN (1965). During the chromatographic purification of myosin from mixed skeletal muscles at least 3 chromatographic fractions can be separated (FAZEKAS *et al.* 1973). Since the myosin fractions are derived from mixed skeletal muscles, it is impossible to decide whether it is because of the different lipid content of the myosin, the varied proportions of protein subunits or the heterogeneity of the heavy chains that the fractions divide into subfractions. The question could not be settled even when the myosin was prepared from a single muscle, because the chromatographic fractions were invariably present (FAZEKAS *et al.* 1974). Furthermore, the ATP-ase activity showed a dependence on the lipid content of the myosin, as reported earlier by KIELLEY—MEYERHOFF (1948).

Fish muscle myosins also contain considerable amounts of lipid, in which there are many unsaturated fatty acids. These lipids can be readily autooxidized. The colour, fluorescence maximum and intensity of their autooxidized products change, and owing to the secondary effect of the products the His, Lys and Met contents of the myosin have been found to be reduced (BRADOCK—DUGAN 1973).

A highly autooxidizable lipid also occurs in rabbit skeletal muscle myosin. According to the method of isolation and the extent of linkage we distinguished a heterogeneous, less closely bound L_1 fraction and a closely with aqueous acetone owing to its cumulative double-bound fatty acid content. It is also certain that the appearance of a faint brown colour in myosin stored for some time, and the change in its fluorescence spectrum, are also related with lipid autooxidation.

On a TLC-plate the L_2-lipid leaves a spot mostly, where phosphatidyl choline occurred. A smaller quantity of material marks the position of the lysophosphatides. The latter is thought to be an autooxidable by-product, because the heterogeneous products of L autooxidized for longer periods stretch over the TLC plate in the form of a long yellow patch. More than 60% of the fatty acids are unsaturated and double-bound. The main saturated fatty acid is palmic acid, and only to a lesser extent stearic acid. Both fatty acids are also found as fatty aldehydes (alkenyl acid phospholipid). The main unsaturated fatty acid is arachidonic acid, and in smaller quantities oleic, linoleic, docosapentanoic and docosahexanoicic acid. In our opinion the lipids of the myosin are responsible for the development of the structure, the tendency to aggregate, and the molecular plasticity of the myosin. The L_1-lipid plays a role in the organization of molecular subunits and in the filamentary organization and aggregation and the L_2 lipid takes part in the organization of the inner structure of the myosin molecule, while their metal chelate complexes, which can be formed simultaneously with the chelates of the peptide chains and substrate, have a part in modifying the molecule.

The Ca^{2+} ion has been found to exercise an influence on the lecithin monolayers, and its chelate-forming effect is correlated with the increasing unsaturation of the fatty acid chains and increases the volume and surface potential of molecules within the monolayer (SHAH—SCHULMAN 1967). Thus, it is probable that the plasticity of the myosin molecule in the presence of the Ca^{2+} ion (SZENT-GYÖRGYI 1951) is related with the formation of the Ca-L chelate.

Although the morphological pattern of the chelate structure changes in *in vitro* experiments to a great extent, becoming heterogeneous as a consequence of autooxidation, this hardly occurs *in vivo*. The basic amino acid L_2 interaction sturcture is still stable when the chelate structure disintegrates. The degradation of the latter is thus delayed, since the interaction of basic amino acids offers some protection against autooxidation.

The origin of the lipids of myosin (particularly that of the tightly bound L_2-lipid) is unknown. It may be synthesized simultaneously with the protein fraction, as MARTONOSI—HALPIN (1972) suggest in connection with the ATP-ase enzyme of the sarcoplasmic reticulum, or the lipid may be transferred to the membrane proteins with the phosphatidyl-choline exchange enzyme after protein synthesis, as suggested by WIRTZ *et al.* (1976).

Our investigations led us to the conclusion that lipids form an integral part of the myosin molecule, necessary for the maintenance of the structure and enzyme activity of the protein, in spite of the fact that the characteristic structure and enzyme activity cannot be regained by returning the lipids (or even KCl). It seems that it is not sufficient to restore the linkage of the lipid and the environment of the protein molecule (pH, ion concentration), since the linkage of the subunits and lipids of such a giant molecule requires more complicated connections if the biological functions are to be restored.

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INVESTIGATIONS ON THE MICRONUTRIENT DEFICIENCY OF PLANTS ON THE PASTURE LANDS OF THE HORTOBÁGY HEATH

By

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A concise report is presented of an extended microanalytical study of the micronutrient content of forage plant samples from the alkaline solonetz grazing lands of the Hortobágy heath in Hungary. The forage plants are on the average deficient in Zn and Cu and undersupplied with Fe. Mn deficiency is modest with the exception of some areas. The plants are well supplied with B and Mo and the soils are well supplied with all the micronutrients, but the alkalinity immobilizes the Fe, Mn, Zn and Cu cations and renders them in this way hardly accessible to the plants. B and Mo remain mobile, being present in anionic form at these pH values. The problems experienced in sheep breeding for many years can be explained by the micronutrient deficiency of the fodder on these grazing lands.

Introduction

The Hortobágy heath is an extended territory (about 50 000 ha) of notoriously bad alkaline clay (solonetz) soils, about 45 km west of Debrecen (Hungary). It is characterized by the unfavourable water economy of the impermeable swelling alkaline clay soil and it is utilized mainly by forage crops, grazed by sheep and cattle. Only small parts of this territory have better soils and are suitable for cultivation.

The chemistry of the Hortobágy soils was intensively studied by Szabolcs, and the literature on these and other alkaline solonetz soils is presented in his book and publications (Szabolcs 1954, 1966, 1972). Although a very copious literature on alkaline solonetz soils exists, particularly from Russian authors (e.g. Bazilevich 1965, Gedroitz 1955) the special micronutrient deficiency of plants growing on these soils has not hitherto been investigated. The unfavourable influence of an alkaline soil pH on the uptake of Zn, Cu, Mn and Fe is recognised in the literature on micronutrient deficiency phenomena (e.g. Sauchelli 1969, Schütte 1964).

This study was aimed at the investigation of the alkaline-clay (solonetz) type of grazing lands on which some pronounced signs of micronutrient deficiency are observable. The forage grass vegetation demonstrates chlorosis and turns entirely yellow in summer drought. It was not clear, however, how much share the deficiency of micronutrients, bad water economy and drought have in this phenomenon. Serious problems have been observed in animal husbandry. The increment percentage of sheep is low and hitherto undiagnosed grave health problems have occurred among both new-born lambs and sheep (neonatal ataxy, inviability, occurs among the lambs, and early infertility etc. in the ewes). These signs appear just as often in the Suffolk strain of sheep recently introduced experimentally as in the customary local Merino strain. The deficiency symptoms observed in this territory render the breeding of

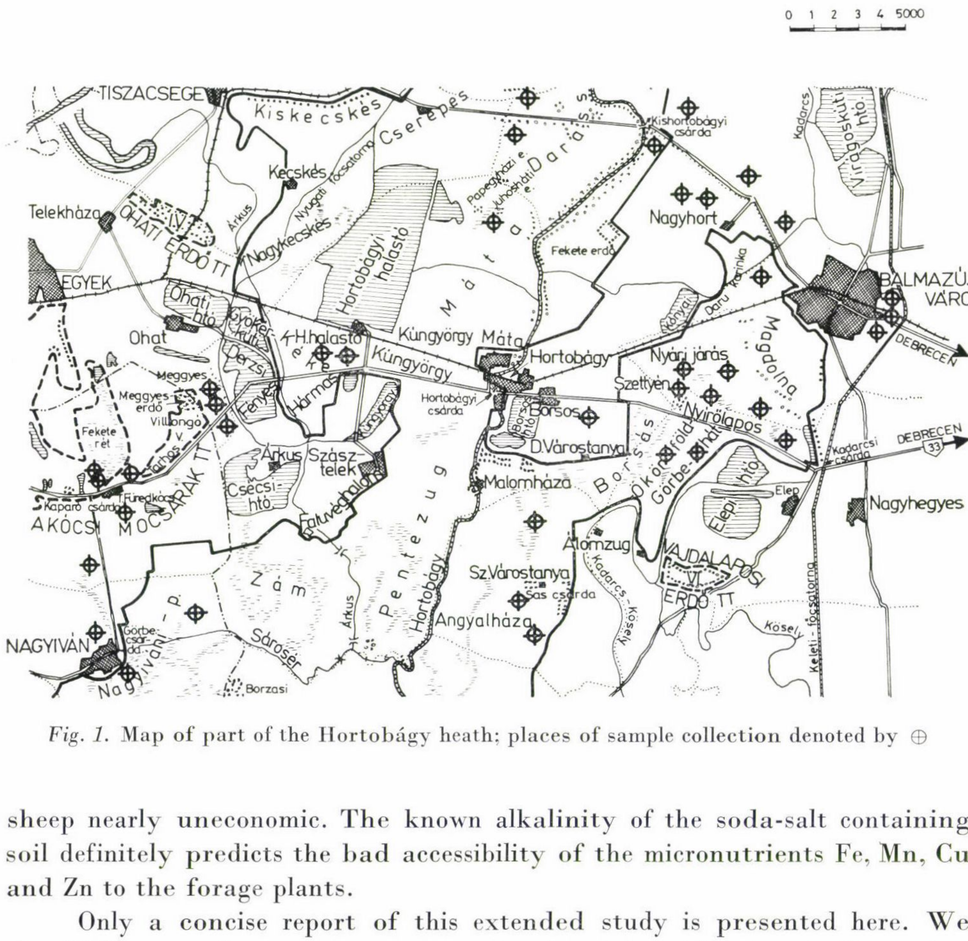

Fig. 1. Map of part of the Hortobágy heath; places of sample collection denoted by $\oplus$

sheep nearly uneconomic. The known alkalinity of the soda-salt containing soil definitely predicts the bad accessibility of the micronutrients Fe, Mn, Cu and Zn to the forage plants.

Only a concise report of this extended study is presented here. We should like to refer in this respect to the detailed publication in Hungarian (Szalay *et al.* 1977) with English summary, in which all figures and tables of the measured data are published in detail, with English legends.

Fig. 1 demonstrates the geographical map of the area. Places where soil and plant samples were collected are denoted by $\oplus$. These places are all pasture grounds. Intensively cultivated better soils are not included in this study.

Material and Method

Soil analyses. 39 soil samples were collected from 13 places and from 3 different depths (0—10, 10—20, 20—30 cm). Investigations of the pH demonstrated that all soil samples were alkaline between pH 7.0—9.0, the majority of them between pH 7—8. The alkalinity is caused by the excessive sodium hydrocarbonate content, with which sodium sulphate and chloride are associated, as discovered in earlier investigations (SZABOLCS 1954, 1972). The average total content of the 39 soil samples amounts to: Fe = 3.0%, Mn = 525 ppm, Zn = 59.7 ppm, Cu = 24.0 ppm, Na = 1.11%, K = 1.46%, Ca = 0.67%. They are well supplied with the micronutrients analysed, but the alkalinity of the soil makes their mobility and uptake by plants very questionable.

Plant analyses. The assumption of an impaired uptake by plants of the micronutrients mentioned was confirmed by the analyses. 366 plant samples were collected in this study from the 37 places denoted by ⊕ in Fig. 1. The plant samples represented a total of 110 plant species belonging to 19 different plant families. They were analysed for micro- and macronutrients, the total study comprising in all 2,000 single analyses.

Each sample contained 20 or more whole plant individuals (without roots) belonging to the same species. They were dried, crushed and 5 g averaged samples were ashed from the crushed powder. After solution of the ashes in HCl the samples were sprayed into the flame of an atomic absorption spectrometer in 0.1 N HCl solution. Calibration was carried out additively by adding a known amount of the micronutrient element in question to the solution.

Each sample was analysed in this way for the micronutrients Fe, Mn, Zn and Cu. Only a limited number of the samples were analysed for B and Mo.

Results

The analyses demonstrated that the samples investigated were well supplied with B and Mo. These elements are known to be mobile in an alkaline environment because they form anions.

As regards Fe, Mn, Zn and Cu, a general deficiency was apparent in the majority of the samples. However differences were observed between species, genus and family, exceeding the considerable extent of scattering of data expressed in the standard deviation. Reference may be made in this respect to the detailed data of the Hungarian publication (SZALAY *et al.* 1977). In Table 1 the mean values of the micronutrient content of all investigated plant samples belonging to the same family are compared. Differences between species and genus belonging to the same family are averaged in this concise table.

It should be mentioned here that the Cu content of *Gramineae* was very low, while on the same soil that of the *Compositae* and *Fabaceae (= Leguminosae)* was higher, nearly normal.

The high Mo accumulating activity of *Fabaceae* is as conspicuous here as the low B content of *Gramineae* and *Cyperaceae*, which is not a deficiency phenomenon, because the mobility of Mo and B is favourable in these alkaline soils. Within the *Fabaceae* family, species belonging to genera of the *Trifolium* sort definitely accumulate more Cu than those of the *Medicago* sort.

The association of plant species (*Achilleo-Festucetum pseudovinae*, Magyar—Soó) (Soó 1934, 1947, MAGYAR 1928a, 1928b) growing on the dry

Table 1

Comparison of the mean values of the micronutrient content of the most important plant families grown on the Hortobágy heath (in ppm/dry subst.)

Plant families	Number of species	Number of samples	Fe, ppm	Mn, ppm	Zn, ppm	Cu, ppm	Mo, ppm	B, ppm
Gramineae	22	122	74	48	14.1	2.8	1.6	7.1
Fabaceae	22	75	159	55	29.6	7.5	3.8	24.0
Compositae	15	46	197	77	38.9	12.4	1.3	28.4
Chenopodiaceae	9	17	363	87	28.6	7.9	1.5	27.0
Cyperaceae	8	35	90	124	17.4	5.5	1.9	9.8
Juncaceae	5	12	59	147	49.7	6.1	3.0	13.1
Caryophyllaceae	4	10	257	100	40.4	4.7	0.7	29.7

alkaline solonetz type of soils on the Hortobágy heath comprises a number of plant species covering the pasture land surface in a proportion influenced somewhat by weather conditions and the time of year and changing somewhat from place to place. *Festuca pseudovina* is the dominating species, covering somewhat more than half of the total green area of pasture lands. By utilizing the coenological estimations it is possible to make an approximate estimation

Table 2

Micronutrient content of the most abundant fodder yielding plant species of the Hortobágy heath pastures (Association of the quantitatively dominating plant species: Achilleo-Festucetum pseudovinae, Magyar — Soó)

Dominating plant species	Green cover, % (estimated)	Fe, ppm	Mn, ppm	Zn, ppm	Cu, ppm
Festuca pseudovina	54.3	111	35	11.7	3.8
Poa pratensis (+ angustifolia)	8.3	69	46	21.9	4.1
Poa bubosa	4.7	91	30	10.3	5.3
Alopecurus pratensis	4.7	73	79	20.6	5.3
Koeleria gracilis	5.4	87	63	20.0	2.2
Agropyron repens	2.4	65	22	9.5	2.0
Potentilla argentea	1.8	96	111	61.3	8.2
Plantago lanceolata	0.2	269	117	32.0	6.8
Achillea setacea et collina	14.2	169	93	29.2	8.6
Centaurea pannonica	1.2	170	44	19.0	8.5
Podospermum canum	0.6	116	48	20.9	7.0
Inula britannica	2.5	192	111	50.8	10.9
Estimated weighted mean value (ppm):		114	51	17.8	4.9

of the percentage contribution of the most abundant plant species in the forage production of the territory. Since the final aim of these investigations was to clarify the deficiency phenomena observed in the animal stock, it was appropriate to make a calculation of the average micronutrient supply of the forage of this grazing land.

Table 2 contains the dominating and more abundant plant species of this territory, with their estimated percentage share in the green cover of the soil surface and their content of the micronutrients Fe, Mn, Zn and Cu, determined in this study. Taking into consideration the percentage shares of the different species, the weighted mean values of the micronutrient contents of the total fodder are represented in the last row of the table.

Conclusions

These investigations definitely established that the fodder of the Hortobágy heath is deficient in several micronutrients, which are essential both for the plants and for the animals feeding on them.

A comparison is given in Table 3 between the normal micronutrient content of pasture land plants growing on a good soil, the marginal concentra-

Table 3

Comparison between the normal and minimal micronutrient content of meadow plants and the needs of grazing animals, as well as the average content of the pastures on the Hortobágy heath (ppm/dry substance)

	Fe, ppm	Mn, ppm	Zn, ppm	Cu, ppm	References
Average of well supplied meadow plants	150—200	70—150	21—40	10—12	Various international sources
Deficiency margin for plants	80	30	20	8	Various international sources
Average of Gramineae (average of 65 samples)	197	72	56	9.4	Szalay et al. earlier studies
Normal requirement of sheep and cattle	50	60	60	7—8	Standpoint of the Veterinary Science Committee of the Hung. Acad. Sci. 1974, see Ref.
Average of fodder on the Hortobágy pastures	113	51	18	5	Table 2 in this study
Micronutrient supply as a percentage of the needs of the animals, by forage of the Hortobágy heath	100%	85%	30%	62%	

tion of deficiency for plants, the normal micronutrient supply essential for sheep and cattle and the content of the Hortobágy heath forage. In the last row of the table the deficient micronutrient supply of the animals grazing on the Hortobágy heath is expressed as a percentage of the essential normal supply.

The deficiency of the plants is the most serious in Zn and Cu and it exists universally everywhere on these grazing lands. The Mn supply seems to be only modestly deficient. The supply of Fe is only about half of that of plants growing on normal good soils but it still seems to be enough for the normal development of both plants and animals. Serious chlorosis due to Fe deficiency occurs at under 80 ppm, according to the literature. Fe deficiency seldom occurs in grazing animals, because they ingest considerable amounts of iron-rich soil and dust with the forage. The B and Mo supply was sufficient in all the samples analysed.

It is well-known that very many factors intervene in the micronutrient supply of plants. Micronutrients are present in abundance in these soils. Of the factors rendering them inaccessible to the plants the pH must be the most influential. Fe, Mn, Cu and Zn hydrolyse in a neutral or here pronouncedly alkaline environment and in these alkaline soda clay soils they are probably precipitated as alkaline carbonates or hydroxides and adsorbed on the surface of the fine colloidal clay mineral particles. The average Ca content of the soils is low (0.67%). There are, however, local differences in the properties of the soils of this vast territory, which was an inundation area of the river Tisza and its tributaries before their regulation. A higher Ca content was found on one area, with a very pronounced Mn deficiency, but with an appropriate Fe supply. The Cu and Zn deficiency, however, was similar to other areas.

These facts clarify the very unfavourable experiences in animal husbandry. It is well-known that Cu, Zn and Mn deficiency causes serious disturbances in the reproductivity and fertility of animals, resulting in a low reproduction rate and early sterility (UNDERWOOD 1971). Cu, Zn and Mn deficiency is a sufficient explanation for the crippled (inviable, neonatal ataxy) lambs and for other health problems (heart insufficiency, etc.) in sheep, which have not yet been thoroughly investigated.

Microanalytical investigations of the micronutrient content of the organs of the animals will soon be undertaken in order to confirm this assumption. It is needless to emphasize that this new knowledge will enable these deficiency phenomena to be corrected by supplying the animals with micronutrients. The economical significance of this knowledge lies in the fact that the Hortobágy heath sustains the largest singly operated sheep breeding stock in Central Europe, consisting of more than 30,000 stock ewes, the fertility of which could be significantly increased with improved health status.

In addition to 1975, continued observation demonstrated increased micronutrient deficiency in plants in the very dry summer of 1976. However the precipitation was exceptionally heavy and well distributed in the summer of 1977 and the micronutrient content of the forage plants increased to about the necessary minimum.

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EFFECT OF LEVEL AND SOURCE OF DIETARY PROTEIN ON SOME BLOOD CONSTITUENTS OF CROSS-BRED LAMBS

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In an experiment with Suffolk × Hungarian Merino lambs, the effect of the level and source of dietary protein on the blood constituents was examined. The results show that by increasing the nitrogen intake, neither the total protein nor the total amino acids in the blood plasma were significantly increased. However, the plasma urea concentration increased significantly. While dietary urea increased the level of the plasma urea, it had no effect on the total protein and total amino acids in the blood plasma.

Introduction

Several studies have been carried out on the protein requirement of ruminants, but the results were not accurate because the measures used respond to many physiological factors. Therefore, many investigators consider it desirable to find other accurate measures based on specific nitrogen components in the body.

Lewis *et al.* (1957), Juhász—Király (1961), Dror—Bondi (1969) found that the concentrations of soluble protein, ammonia and soluble amino N in the rumen fluid and of urea in the blood increased with increasing dietary protein for adult ruminants. They also found that dietary protein was correlated with these N metabolites. However, Price (1971) indicated that the amino N-level decreased in the abomasum when the crude protein content of the diet of 6 mature sheep was raised from 14 to 24%. Potter (1971) found that the total free amino acid concentration in the jugular vein plasma was lower when the feed contained urea.

Blood urea nitrogen BUN is a sensitive indicator of protein adequacy as indicated by Juhász—Király (1961) and later by Preston—Pfander (1963). Preston *et al.* (1965) found in their experiment that BUN values above 10 mg/100 ml indicated an adquate protein intake in the rations fed to lambs. Ruminants can utilize part of the blood urea as a source of nitrogen (Houpt 1959, Juhász 1965, Caffrey *et al.* 1967). Juhász (1962) found that after two days of fasting the blood urea concentration increased in ruminants. Leibholz (1970) observed that long periods of starvation and a low nitrogen diet both resulted in a reduction of the plasma urea concentration.

McIntyre—Williams (1971) stated that the rate of urinary urea excretion was linearly related to the plasma urea concentration and urine flow. The work of Dror—Bondi (1969) indicated that protein degradation in the rumen and the removal of urea by the kidneys were limited when excessive amounts of protein were fed.

The object of our experiments was to study the effect of the level and source of dietary protein on the total protein and the total amino acid and urea concentrations in the blood plasma of lambs, and to determine whether these blood components are quantitatively related to the dietary protein intake.

Materials and Methods

The animals used in this study were chosen from a fattening experiment, carried out on Suffolk × Hungarian Merino lambs. The experimental stock was divided into ten groups 4 male lambs in each, corresponding to ten treatments. The treatments were two levels, 13.9 and 16.5%, of dietary protein, with or without urea, and with or without a dietary supplementation of methionine. The lower (13.9%) protein level was fed to groups A, B, C and D, the higher (16.5%) protein level to groups E, F, G and H. Two control concentrates were also fed to groups K_1 and K_2. The diets were offered in pellet form twice a day, together with ad libitum feeding with third class alfalfa hay. The components of the ten diets are shown in Table 1, while the results of the chemical analysis are shown in Table 2.

The samples from the jugular vein were taken from each of the four lambs in each group, four hours after feeding, on the 23rd and 63rd day of the experiment.

The total protein, total amino acid N and urea in the blood plasma were determined as described by Bálint (1962), with some modifications taken from Juhász—Szegedi (1965).

Results

Total protein and total amino acid N concentration in blood plasma. As shown in Tables 3 and 4, the concentration of the total protein in the blood plasma increased as the dietary protein level rose. However, the differences between the groups were not significant, as was shown by an analysis of variance. The values obtained were in the range of normal concentrations.

From Tables 3 and 4, it also appears that the concentration of total amino acid N in the blood plasma was not affected by the different treatments. The concentration was not changed by increasing the level of dietary protein. These results are in accordance with those reported by Ogilvie *et al.* (1960), who found that the addition of excessive amounts of soybean meal to the diets of steers did not affect the total free amino acid concentration in the plasma. At a 13.9% dietary protein level, methionine supplementation resulted in an increase in the plasma amino acid concentration in groups B and D. This trend was not found at the higher protein level (16.5%). Schelling *et al.* (1967) stated that "although the evaluation of plasma amino acid concentration and rumen microbial amino acid contents may be useful for the detection of limiting

Table 1

The components of the rations (compound feeds)

Ingredient %	A	B	C	D	E	F	G	H	K_1	K_2
Maize	46.6	45.6	40.6	39.6	46.6	45.6	35.0	34.0	45.0	70.0
Barley	24.0	24.0	29.0	29.0	12.0	12.0	23.0	23.00	—	—
Wheat	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	—	—
Hay meal	5.0	5.25	5.0	5.25	5.0	5.25	5.0	5.25	45.0	25.2
Sunflower meal	17.0	17.0	6.5	6.5	29.0	29.00	12.0	12.0	—	—
Soybean meal	—	—	—	—	—	—	—	—	7.6	—
Starch	—	—	10.0	10.0	—	—	15.6	15.6	—	—
Urea	—	—	1.5	1.5	—	—	2.0	2.0	—	2.0
Sodium sulphate	—	—	—	—	—	—	—	—	—	0.4
Lime	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Salt	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
XIX-Vitamin (1) premix	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
AP-18-Mineral (2) premix	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Biomethin (3)	—	0.75	—	0.75	—	0.75	—	0.75	—	—

1. *Composition of XIX-Vitamin premix*

Vitamin A	1,500,000 IU
Vitamin D_3	300,000 IU
Vitamin E	5,000 IU
Zincbacitracin	4,000 mg
Manganese	6,000 mg
Iron, Iodide, Cobalt, Zinc and antioxidant	

2. *AP-18-Mineral premix/kg*

Foszkal (dicalc. phosphate)	600,000 mg
Monocalcium phosphate	300,000 mg
Magnesium	30,000 mg

3. 20% methionine

1, 2 and 3 are the products of PHYLAXIA (Budapest)

Table 2

Crude chemical composition of the rations (compound feeds)
%

Groups	Dry matter	Crude protein	Ether extracts	Crude fibre	Ash	NFE
A	90.3	14.0	4.3	5.5	4.3	62.2
B	91.5	13.8	4.0	5.5	4.9	63.3
C	90.8	13.8	3.4	4.1	4.0	65.5
D	90.5	14.0	3.2	4.2	3.8	65.3
E	91.0	16.4	4.5	6.7	4.7	38.7
F	91.5	16.9	4.7	6.8	5.2	57.9
G	91.5	16.4	3.0	4.4	4.2	63.5
H	91.4	16.4	3.7	4.6	4.4	62.3
K_1	92.5	16.1	4.2	11.9	6.2	54.1
K_2	92.5	17.0	4.3	9.1	5.9	56.2

Table 3

Certain parameters of blood plasma in the different groups (mean concentrations and standard errors)

On the 23rd day of feeding

Groups	Total protein, g/100 ml	Total amino acid N, mg/100 ml	Urea, mg/100 ml
A	7.61 ± 0.46	9.19 ± 1.56	49.5 ± 6.30*
B	7.85 ± 0.38	12.09 ± 0.98	46.9 ± 3.91*
C	7.60 ± 0.54	11.09 ± 0.62	66.5 ± 1.75*
D	7.62 ± 0.48	12.15 ± 0.33	59.7 ± 6.79*
E	7.69 ± 0.45	11.33 ± 0.58	62.2 ± 2.78*
F	9.36 ± 0.48	10.31 ± 0.35	55.7 ± 4.84*
G	10.23 ± 0.85	9.08 ± 0.52	72.7 ± 5.21*
H	9.59 ± 0.44	9.39 ± 0.98	60.3 ± 5.32*
K_1	11.94 ± 0.77	9.11 ± 1.15	70.6 ± 3.62*
K_2	10.97 ± 0.59	8.86 ± 0.40	87.4 ± 13.97*

* Significant at a 1% level; $F = 3.66$

amino acids in ruminants", the proof of whether such a condition exists will have to come about by the administration of amino acids in such a way that they are not available to the intraruminal metabolism, thus ensuring that these amino acids are available to the host animal.

Table 4

Certain parameters of blood plasma in the different groups (Mean concentrations and standard errors)

On the 63rd day of feeding

Groups	Total protein, gm/100 ml	Total amino acid N, mg/100 ml	Urea, mg/100 ml
A	9.19±0.97	10.74±0.59	42.6±3.27*
B	7.41±0.30	12.18±0.82	40.3±3.18*
C	8.91±0.93	11.93±0.60	52.3±2.67*
D	8.72±1.01	9.91±0.75	48.8±4.56*
E	9.83±0.58	11.62±0.51	54.8±3.81*
F	10.11±0.49	12.00±0.22	56.3±2.10*
G	10.59±1.01	12.48±0.79	61.1±5.64*
H	10.63±0.33	11.50±0.85	56.7±2.24*
K_1	10.05±0.37	12.65±0.83	59.6±8.81*
K_2	10.20±0.99	11.42±0.76	64.6±2.30*

* Significant at a 5% level; F = 3.05

Urea concentration in blood plasma. By increasing the protein level in the ration, the urea concentration in the blood plasma was increased (Tables 3 and 4). The analysis of variance indicated significant differences in the plasma urea concentration as affected by the different treatments. These results were in accordance with those reported by Juhász—Király (1961), McDonald (1969), Dror—Bondi (1969), Leibholz (1970) and McIntyre (1970), who found a highly significant positive correlation between the blood urea and the nitrogen intake of lambs. At the same dietary protein level, it was found that dietary urea resulted in an increase in the blood urea concentration, while dietary methionine supplementation resulted in a lower blood urea concentration. The addition of 0.4% sodium sulphate was also favourable for group K_2, in which the lambs received 2% urea in the ration. The effect of sodium sulphate in improving the urea utilization gave the same results as methionine with respect to the increase in the growth rate of the lambs (Mahmoud—Mihálka 1976).

It was found that the concentration of urea in the blood plasma decreased in all the groups after 63 days of feeding. This may be due to the higher protein requirement of the lambs during that period and to their higher body weight. When the diet had a higher protein content and the nitrogen was available to the animal in excess of its requirements, the excess of nitrogen was converted mainly into urea and the blood urea nitrogen was high. Dror—Bondi (1969) stated that protein degradation in the rumen and the removal of urea by the kidneys were limited when an excessive amount of protein was fed.

While blood urea is an accurate indicator for the level of dietary protein intake, the use of this measurement as a technique for assessing protein quality requires the work to be carried out under standardised conditions, as found by EGGUM (1970). His results on rats showed an inverse relation between the blood urea content and the biological value of the diet, which is sufficiently accurate to provide a useful method for the prediction of protein quality.

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BIOPOLYMER — METAL COMPLEX SYSTEMS. II. PHYSICAL PROPERTIES OF HUMIC SUBSTANCES AND THEIR METAL COMPLEXES

By

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The molecular weight (mwt) and mwt distributions of humic substances and metal humates of different origin have been determined as a function of pH and electrolyte concentration by analytical ultracentrifugation and gel filtration methods. 1. Average mwt, particle size and form factors point to the presence of molecular aggregates in aqueous solutions at low pH values. These aggregates rapidly decompose at higher pH values. 2. The change in the mwt of humic acids of various origin and age and their behaviour as a function of pH values support the fact that in addition to the age of the sample, all conditions prevailing during the complex transformation must be taken into consideration in the interpretation of the colloidal structure. 3. Trivalent metal ions almost exponentially increase the mwt of humic acids, while divalent cations cause only a linear increase. The effect of magnesium ion is negligible even at higher electrolyte concentrations. 4. Polydispersity has been investigated by dextran gel filtration and mwt distribution of the samples has been determined.

Introduction

Humic substances of different origin (soil, peat, lignite, brown coal) vary in many respects; however, similarities in their physical properties point to macromolecular structures. Humic acids are generally composed of a large number of higher mwt particles.

In the study of natural macromolecular substances, the following parameters must be determined: ultimate analytical composition and average mwt, i.e. relative mass of particles in daltons, the mwt distribution, as well as particle size and shape. These factors have a considerable effect on the physical properties, i.e. specific gravity, optical density, colour, solubility, thermal and electrical characteristics, etc.

Available data (Schnitzer—Khan 1972) show that it is very difficult to obtain reliable values for the mwt of humic substances. Different methods carried out on the same types of humic substances afforded different mwt values, sometimes showing deviations of several orders of magnitude. This may be due to the place of origin, possible contaminations and the age of the samples, which may, further, suffer various degrees of degradation in the course of extraction, purification and treatment in aqueous solutions with different pH values.

Among the methods used are those measuring the number-average $\bar{M}_n$ (cryoscopy, osmometric pressure, diffusion, isothermal distillation), weight-average $\bar{M}_w$ (viscosity, gel filtration) and the Z-average $\bar{M}_Z$ (sedimentation) mwts. For homogeneous systems $\bar{M}_n = \bar{M}_w = \bar{M}_Z$, while for heterogeneous systems such as humic substances: $\bar{M}_n < \bar{M}_w < \bar{M}_Z$.

The mwt of humic acids has been determined from the rise in the boiling point (FUCHS 1928) and by vapour pressure osmometry (SAMEC 1930). WELTE (1952) carried out measurements on the sedimentation of humic acids in alkaline solutions; however, owing to the high polydispersity of the system and the dark colour of the substance, the results were not quite reliable. Evaluable data could be obtained only with an optical system constructed and further developed by Philpot and Svenson.

POSNER—CREETH (1972) carried out the mwt determination of humic acids by equilibrium ultracentrifugation. Mwt distribution of humic acids and their alkaline salts were determined in aqueous solution by Archibald's ultracentrifugation method (REBACHUK—MAXIMOV 1972).

Several authors studied the mwt distribution of humic substances by the gel filtration technique (CAMERON 1972, GJESSING 1965, GJESSING 1970, ISHIWATARI 1971, KHAN—SCHNITZER 1971, LADD 1969, LINDQUIST 1967, LINDQUIST—WESSLEN 1971, MEHTA 1963, POSNER 1963, RASHID—KING 1969, RASHID—KING 1971, SEIDEL 1966, SWIFT—POSNER 1971, SWIFT *et al.* 1970, WERSHAW—PINCKNEY 1971).

In the course of our investigations, the average mwts of fulvic, hymatomelanic and humic acids from lowland peat, lignite and brown coal, as well as their metal compounds were studied by means of an analytical ultracentrifuge and by the gel filtration technique. In order to describe the shape of the macromolecule we calculated the frictional factors f and f_0 of some samples from results obtained in our sedimentation experiments. The ratio of these values may offer more reliable information on the morphology than the data obtained by viscosimetry.

The purpose of our studies on metal-humic acid systems was to determine the effect of metal ions on the mwt as a function of the concentration of metal salt as a strong electrolyte.

Materials and Methods

Preparation, extraction and purification of the samples (lowland peat from Úsztató-major, Keszthely: lignite from Ecséd and brown coal from Tatabánya) were published in the first part of this series (LAKATOS et al. 1977). See also DUCHAUFOUR—JACQUIN (1966), JOHNSON—KNOJEWYJ (1966), LINDQUIST (1968), PLEVEN et al. (1967), STEVENSON—BUTLER (1965), SEIDEL (1966), SIPOS—SIPOS (1967), SIMHA (1945), SIPOS—SIPOS (1968).

Purified humic acids obtained from lowland peat are practically monodispers, precipitated from aqueous solution at pH = 2.7. Humic acids extracted from different types of lignite and brown coal, on the other hand, were found to be considerably polydispers, a certain amount of precipitation could already be observed at pH = 8, which points to higher-mwt humic acid fractions. Precipitation in major fractions started only below pH = 5 and proceeded in minor fractions up to pH = 1. Practically monodispers fractions suitable for ultracentrifugation, therefore, required the precipitation of several humic acid fractions.

Prior to the examinations, the samples must be desalinized with cation and anion-exchange resins or by means of dialysis, owing to the considerable amount of sodium chloride formed in the course of preparation and purification. According to FLAIG and BEUTELSPECHER (1968), for example, the addition of 0.2 M sodium chloride to a humic acid fraction of 4800 mol. wt. at pH 4.5 leads to an approx. 15-fold increase in mwt.

The hydrogen ion concentration of the desalinized samples was adjusted with hydrochloric acid or sodium hydroxide, and mass concentration ranged between 0.1—1 g/100 cm^3. All solutions were allowed to stand for 48 hours and were measured at 25°C.

The mwt of metal humates and humic substances doped with various metal ions were determined as a function of electrolyte concentration. An aqueous solution of metal salt (0.1—10 cm^3 0.02 M) was added dropwise to a solution of desalinized humic acid (10 cm^3, 0.075% at pH = 2.6). The concentration of the strong electrolyte was given for the total volume. From the total acid number (8.8 mequ/g for peat I-humic acid, 8.0 mequ/g for peat II-humic acid, 7.9 mequ/g for lignite humic acid and 6.6 mequ/g for brown coal humic acid (LAKATOS *et. al.* 1977)), the electrolyte concentration and the equilibrium constants, quantitative relations in the solution could be derived. Unfortunately, however, we have no exact knowledge of the latter parameters, except for low mwt fulvic acids (GAMBLE *et. al.* 1970). The addition of metal salt was stopped immediately before precipitation of the metal humates. All humate solutions were allowed to stand for 48 hours before measurements, as aggregation caused by electrolytes is a considerably slow process. After determination of the pH values, the solution was ultracentrifuged. The mwts of metal humates were determined in an electrolyte concentration range where no precipitation takes place, i.e. the system is in a colloidal state, immediate sedimentation of the metal humate precipitates in the field of centrifugation, would, namely, render measurements impossible. Therefore, the range of electrolyte concentration was first determined by turbidimetry.

In our investigations, we used a MOM (Hungarian Optical Works) type G-120 analytical ultracentrifuge. On the basis of Svedberg's relation, the average mwts could be calculated from the sedimentation and diffusion constants determined at different hydrogen ion concentrations. These values were also determined by Archibald's method, and from the sedimentation equilibrium (ELIAS 1961).

Mwt distribution studies were carried out by Sephadex G25 Dextran gel filtration with an SF 62 automatic fraction collector (made in Czechoslovakia). The concentration of humic acid fractions was determined from the visible light absorption coefficient (λ = 450 nm) with a Zeiss-Spekol spectrophotometer on the basis of a calibration curve. The distribution curve was obtained from the concentration values plotted against elution volumes.

Specific gravities were determined by pyknometry. Freeze dried or powder samples were compressed into disks, under 910 kg/cm^2 pressure in 10 mm vacuum, then dried over phosphoric pentoxide in an exsiccator for 1 day.

Solubility was determined by weight measurements on the solid phase.

Results

Based on their solubility, in the order of increasing mwts, humic substances may be subdivided into the following groups: fulvic, hymatomelanic, brown and grey humic acids and, finally, insoluble humic substances. Table 1 summarizes average mwt values of lowland peat humic substances determined by sedimentation equilibrium at constant hydrogen ion concentration. The mwt of I-humic acid is higher than that of II-humic acid, owing to its higher protein content. Removal of the protein content by boiling with mineral acids results in a degraded and hydrolysed lower-mwt humic acid. Hymatomelanic acids obtained by extraction and those yielded by fermentation proved to be different products also on the basis of their mwts (LAKATOS *et al.* 1977). Specific gravity values and ultimate analytical data of lowland peat humic substances are also collected in Table 1.

We studied the change in mwt as a function of time, in acidic solution at room temperature and constant pH values (Table 2). In the case of lowland peat brown humic acids, no change could be detected for about 3 weeks after the first measurement. Due to slow aggregation, however, a considerable increase could be observed in 8 weeks and after the elapse of 80 days, the mwt showed an almost 3-fold increase.

Table 1

Physical properties and ultimate analytical data of peat humic substances ($pH = 2.7$; $T = 298$ °K; $t = 1$ week)

Properties	Fulvic	Hymatomelanic		Brown humic acid				Gray humic acid
		Extracted	Ferm.	I.	II.	Hydr.	III.	
$\bar{M}$	640	800	1100	3700	3100	1100	2200	>10000
a) sp. gr.								
g/cm³	1.58	1.57	1.56	1.43	1.54	1.49	1.53	1.6
b) Ash. %	1.43	1.97	1.22	1.1	0.8	4.6	2.3	31.1
Fe %*	$1 \cdot 10^{-6}$	$1 \cdot 10^{-3}$	$1 \cdot 10^{-6}$	$5 \cdot 10^{-3}$	10^{-3}	10^{-1}	10^{-5}	10^{-1}
C %	38.0	52.2	43.5	49.4	47.5	48.8	51.5	32.2
H %	5.6	5.8	4.4	4.8	4.0	4.5	3.9	4.3
N %	0	2.1	2.5	2.4	1.8	1.8	3.5	3.2
S %	3.0	tr.**	0.5	2.1	1.6	1.9	2.2	tr.
Cl %	tr.	tr.	tr.	tr.	tr.	1.6	0.9	tr.
O %	52.0	40	47	40.8	45.0	36.8	35.8	31.2

* Transition metal contamination 10^{-3} %
** tr. = traces

Table 2

The change in mwt of peat brown humic acids as a function of time ($pH = 2.7$; $T = 298$ °K)

Days	I-humic acid	II-humic acid
0	3300	3100
23	3400	3100
56	5000	4500
80	8000	8780

Table 3

The change in mwt of peat II-humic acid with pH values
(T = 298 °K; t = 80 days)

pH	2.70	5.00	5.50	6.00	6.50	7.00	7.50	8.00
$\overline{M}$	8780	4450	4100	3900	3600	3530	3100	2700

Table 4

The change in mwt with pH values of samples of different ages
(T = 298 °K; t = 80 days)

Brown humic acid sample	Ash %	pH			
		5.0	5.5	6.0	6.5
a) Peat (Keszthely)	0.8	4450	4100	3900	3600
b) Lignite (Ecséd)	0.9	7650	5610	3340	2150
c) Brown coal (Tatabánya)	1.0	8350	7900	7200	5300

After the 80 days, with the increase of the pH value the aggregate became disaggregated and depeptized (Table 3). The mwt of humic substances showed a considerable change as a function of the hydrogen ion concentration.

The change of mwt with hydrogen ion concentration, in the case of peat, lignite and brown coal humic acids, are collected in Table 4. As is evident from the Table 4, the mwt generally increases with the age of the sample. Mwt decreases with the increase of pH value; it is highest in the case of a lignite sample with a medium degree of carbonization, lower in an older and more carbonized brown coal sample and lowest in young peat humic acids.

In addition to cohesive forces between the individual molecules and aggregates, contaminations (metal traces, bitumen, etc.) hindering disaggregation, must also be taken into consideration.

This is also supported by the lyophobe character of brown coal humic acids and the considerably high ash content of the high-mwt samples.

Table 5 indicates the sedimentation (S) and diffusion (D) constants of lignite humic acids as well as average mwts ($\overline{M}$) determined by three different methods, particle size ($\overline{r}$) and friction ratios (f/f_0) as a function of pH values. As can be seen, sedimentation constants, average mwts and particle size decrease with the increase of pH values. On the other hand, the diffusion constants increase proportionally with the increase in pH value. These results are in agreement with earlier experiments, according to which the molecule is more aggregated at lower pH values, while it becomes peptized and the particle weight and size decrease at lower hydrogen ion concentrations.

Table 5

The change in mwt and morphologic parameters of lignite at different pH values
($T = 298$ °K; $t = 1$ week)

pH	5.0	5.5	6.0	6.5
$S \cdot 10^{-13}$	2.16	1.95	1.62	1.35
$D \cdot 10^{-6}$	3.14	3.75	4.35	5.72
$\overline{M}$ (Archibald)	6250	4860	3120	2300
$\overline{M}$ (Sed. equ.)	7650	5610	3340	2150
$\overline{M}$ (Sed. vel.)	6170	4800	3350	2400
$\bar{r}$ (Å)	60	45	39	27
f/f_0	1.25	1.17	1.1	1.05

The above considerations are also supported by the ratio of f/f_0 characteristic of the shape of the molecule, namely, at lower pH values, where the molecules form relatively large aggregates, asymmetry of the molecule is more probable. E.g. at pH = 5 this value is 1.25, which means that the particle shows the greatest spherical aberration. At higher pH values, the axial ratio gradually decreases and at pH = 6.5 the molecule is almost completely spherical. With consideration of the formula introduced by SIMHA (1945), axial ratio 5 would correspond to factor 1.25 and axial ratio 2 to factor 1.05. At this point, molecular aggregates almost entirely disappear and the particle size is reduced approximately to half its value.

It may be unambiguously stated that the change in the mwt of humic acids with the pH value has a great effect on their colloidal state. Large molecular aggregates formed at lower pH values fall into smaller fractions at higher pH values due to peptization. Naturally, only a certain portion of the particles are aggregated, as the H^+ ions or metal ions are more likely to form non-bridged bonds than bridges between the particles. Thus, the measured $\overline{M}$ shows a continuous slow change against H^+ or metal ion concentration. This assumption is verified by sedimentation and diffusion constants, average mwt values, particle size and form factors.

Similarly to hydrogen ions, due to their positive charge, the different cations exert a more or less aggregating effect on the negative charge of colloidal humic particles. This effect depends on the nature, charge and radius of the ions, in other words, on the polarization properties, i.e. polarizing power and polarizability of the cations. Measurements were carried out in aqueous solution, where parameters of the hydrated ion must also be taken into account.

Trivalent cations e.g., aluminium(III), iron(III), and chromium(III) ions cause considerable aggregation (Fig. 1). While a considerable increase in the concentration of aluminium(III) and chromium(III) ions leads to a nearly exponential increase in the mwt, the effect of iron(III) ions gives a sigmoid curve (Fig. 1). In the latter we must also consider the formation of iron(II) ions caused by reduction with humic acids, which results in partly mixed iron(II) and iron(III) humates (see Biopolymer — metal complex systems. Part IV.).

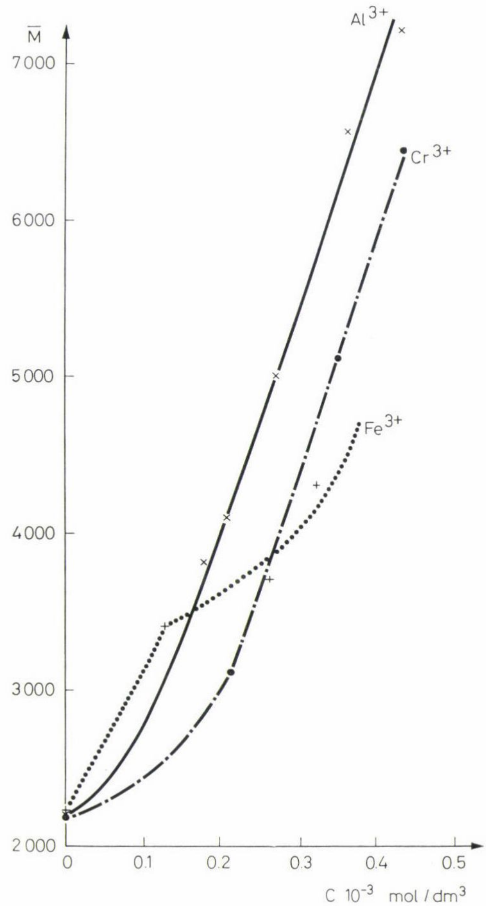

Fig. 1. Change in average mol. wt. of III-humic acid doped with trivalent metal ions at pH 2.7, as a function of metal ion concentration. Abscissa: metal ion concentration 10^{-3} mol/dm^3. Ordinate: average molecular weight

The aggregating effect of divalent transition metal cations decreases in the following order: copper(II) > iron(II) ~ cobalt(II) ~ nickel(II) > zinc(II) > manganese(II), and this is approximately the order of stability constants of humic acid — metal complexes (see Biopolymer — metal complex systems Part VIII.). As can be seen in Fig. 2, with the increase in concentration of divalent cations (except for iron(II)) a nearly linear mwt increase can be observed.

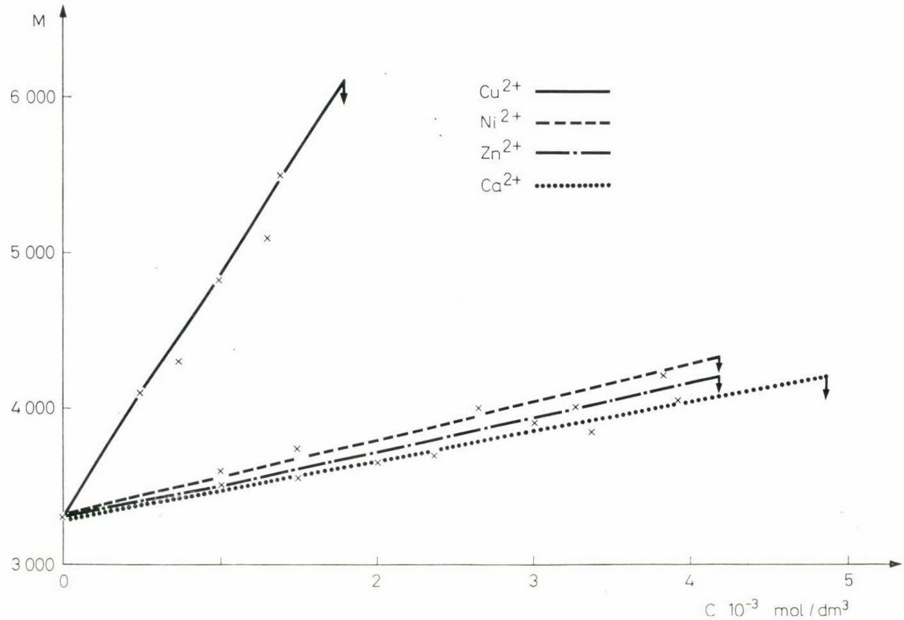

Fig. 2. Change in average mol. wt. of I-humic acid doped with divalent metal ions at pH 2.7, as a function of metal ion concentration. Abscissa: metal ion concentration 10^{-3} mol/dm^3. Ordinate: average molecular weight

Table 6

The change in mwt of peat brown humic acid with the concentration of alkaline earth metals ($pH = 2.7$; $T = 298$ °K; $t = 1$ week + 2 days)

Electrolite	Electrolite Conc. 10^{-3} mol/dm^3	$\overline{M}$
—	0	2200 (III-humic acid)
$CaCl_2$	0.35	2960
	0.76	3700
	1.50	4500
	1.41	6000
	1.63	a) precipitated
$Mg(ClO_4)_2$	3.6	2100
	5.0	2000
	9.0	a) precipitated
—	0	3300 (I-humic acid)
$CaCl_2$	1.50	3550
	2.35	3700
	3.35	3850
	3.92	4050
	4.87	a) precipitated
—	0	3700 (I-humic acid)
$Mg(ClO_4)_2$	10	3700
	14	3600
	16	a) precipitated

The effect of calcium and magnesium ions has been studied (Table 6). It is evident from Table 6 that while calcium ions cause a linear increase in mwt, similar to the aggregation of divalent transition metal ions (Fig. 2), magnesium ions do not result in any aggregation. A similar phenomenon can be observed in the case of Mg^{2+} and clay minerals. A probable explanation of this observation is the large size of hydrated magnesium ions (r = 0.428 nm), and thus, their weak polarizing effect (see position of the magnesium ion in the lyotropic series).

Similar correlations can be observed between the concentration of different metal ions and the mwt of humic acids obtained from samples of various ages (Fig. 3). Examinations were carried out at pH = 5, since at lower pH

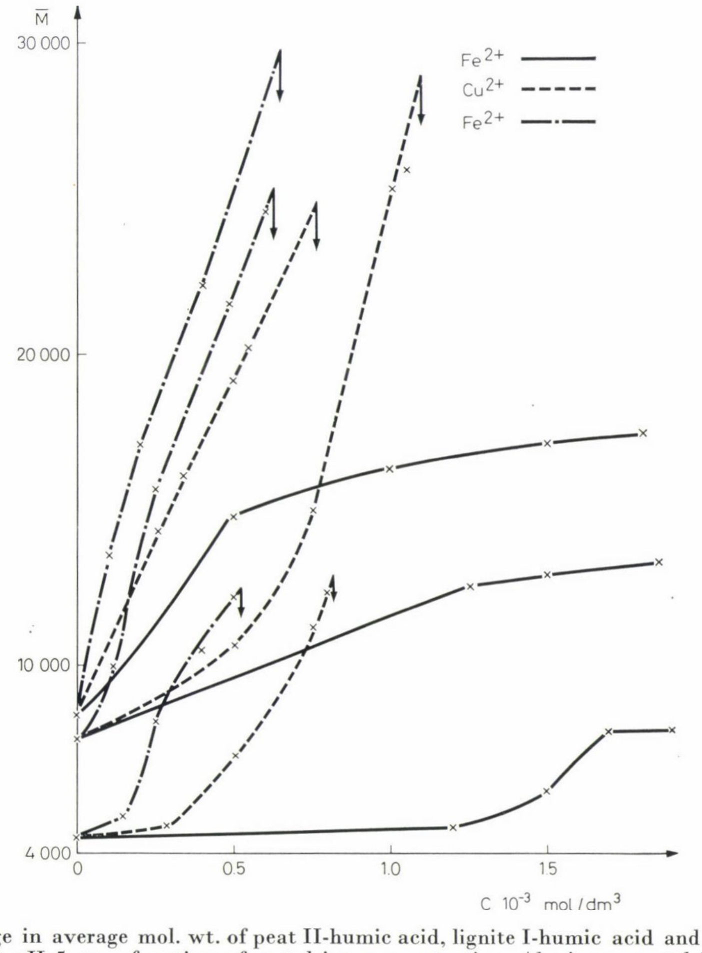

Fig. 3. Change in average mol. wt. of peat II-humic acid, lignite I-humic acid and brown coal humic acid at pH 5, as a function of metal ion concentration. Abscissa: metal ion concentration 10^{-3} mol/dm³. Ordinate: average molecular weight Fe^{2+} — • — contains Fe^{3+} too.

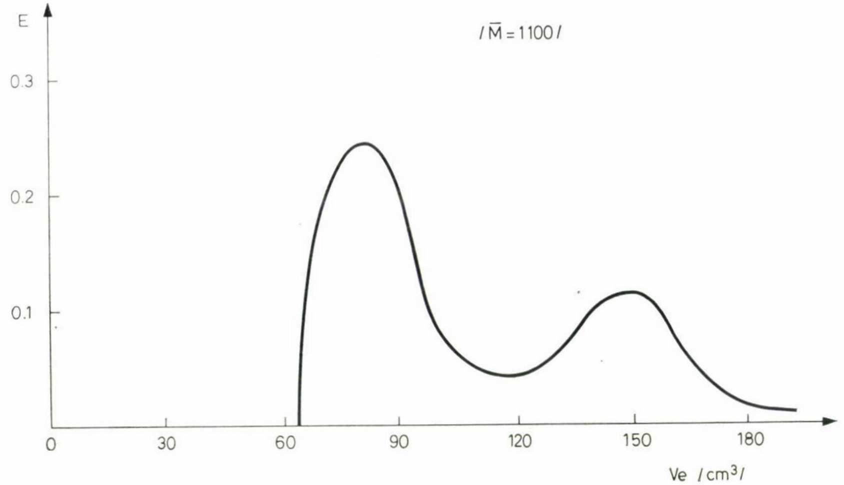

Fig. 4. Molecular weight distribution curve of fermentation peat humic and hymatomelanic acids as a function of elution volume (V_e)

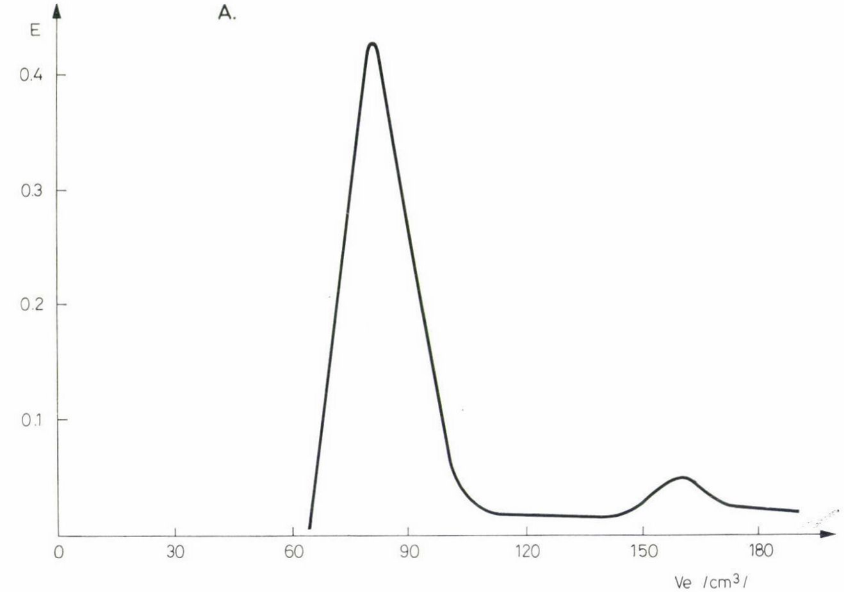

Fig. 5. Molecular weight distribution curve of fermentation peat humic and hymatomelanic acids doped with copper-II ion, as a function of elution volume

values measurements were difficult to perform due to the rapid sedimentation of lignite and brown coal humic acids.

Our dextran gel filtration studies on fermentation humic acids with 1100 dalton average mol. weight show that these compounds are composed of a 70% higher mol. weight brown humic acid fraction and a 30% lower mol. weight hymatomelanic acid fraction (Fig. 4). This fermentation hymatomelanic acid doped with e.g. copper(II) ions leads to a practically monodisperse fraction (Fig. 5)

Further gel filtration experiments on lignite and brown coal humic acids. are in progress.

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VARIA

INDUCED MUTATION IN THE ROSE CV. GULZAR AND EFFECTS OF CHEMICAL AND PHYSICAL MUTAGENS ON PLANT GROWTH

A number of new varieties of ornamental plants produced and released as a result of the induction of mutations have been listed by SIGURBJORNSSON—MICKE (1969). In roses too a number of mutants have been obtained by NAKAJIMA—KAWARA (1965) and by many other workers (NAKAJIMA 1965, 1966, NISHIDA *et al.* 1967, CHAN 1966, STREITBERG 1966a, b, c, NYBOM 1970, SAITO 1970, NYBOM—KOCH 1965, DOMMERGUES *et al.*, 1967, GUPTA—SHUKLA 1970, SWARUP *et al.* 1971, KAICKER—SWARUP 1972, SWARUP *et al.* 1972). BROERTJES (1970) suggested that all possible measures should be taken to decrease diplontic selection and thus offer the mutated cell a maximum chance of taking part in shoot formation. The present study was undertaken to see the effect of both physical and chemical mutagens on growth and induction of mutation in the rose cv. "Gulzar"(a hybrid seedling from the cross Kiss of Fire × Prelude released by I. A. R. I.).

Budwood of "Gulzar" was treated during December 1970 with gamma rays in a gamma cell, fitted with a 2000 curie source of Co^{60} in August 1963, at the Division of Genetics, I. A. R. I. (delivery 2 to 2.2 kr/min.). The irradiated buds, about 100 per treatment at 5, 7.5 and 10 kr, were removed from the scion wood and T-budded on Edward rootstock. In the second method scion wood with dormant buds was dipped in a 100 ml beaker containing various concentrations of EMS (ethyl methane sulphonate) prepared in 0.1 M phosphate buffer, with

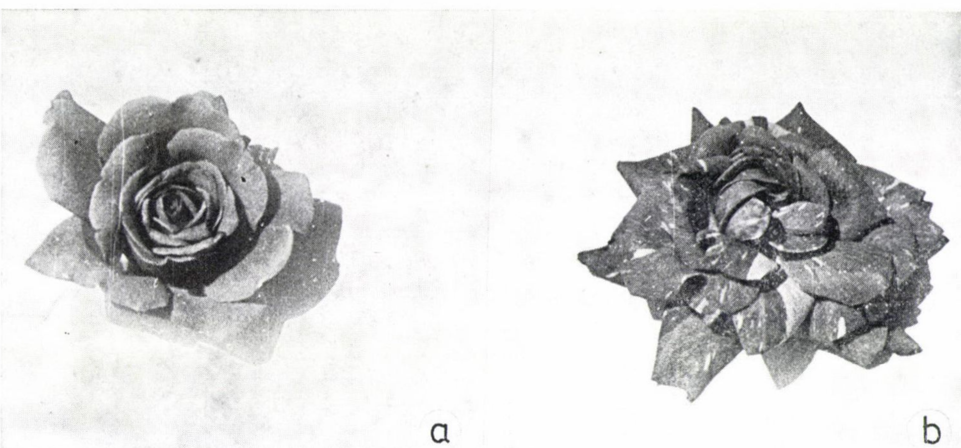

Fig. 1. The chimeric appearance of the mutation. a) "Gulzar" control, b) Striped "Gulzar" (after E. M. S. 0.25% TRT)

a pH of 7. Scions dipped for 16 hrs in 0.25, 0.5 and 1% solutions of EMS were kept at a room temperature of 25°—28°C. In another method, after irradiation (5 kr gamma rays) chemical treatment with 0.25% EMS was applied. The method suggested by WESTWOOD *et al.* (1963) was utilized to determine the bush volume after one year of growth of treated buds. The significance of the treatment was calculated by applying the the "t" test.

The presence of florachrome A and B in the control and mutants of Gulzar was studied by using RAMAN's (1970) technique, which was also adopted by KAICKER—PANDEY (1973). 0.5 g fresh petals were crushed and extracted in 15 ml of acetone to extract the floral pigments, which were quantitatively estimated spectroscopically using a "Spectronic 20" (B and L) at 630 to 570 nm respectively.

Percentage bud take. Table 1 gives observations on the percentage bud take, the frequency of mutation and the phenotypic expression of the mutants. It is noticed that the sprouting of the buds generally decreased with the increase of both chemical (EMS) and physical (gamma irradiation) mutagen treatments, though it was slightly greater in the 0.5% EMS treatment than in the lowest dose of 0.25%. There was no sprouting of buds in the 10 kr treatment. The post irradiation (5 kr) treatment with 0.25% EMS gave 6% sprouting of buds.

Rate of sprouting, survival and growth. While in the chemical mutagen treatment the buds sprouted immediately after 15—20 days of treatment, those in the 5 kr and 7.5 kr gamma ray treatments took about 5—6 months in some cases. However, no such perceptible difference was observed in the case of chemical treatments (EMS 0.25%) after irradiation (5 kr). Two plants in the gamma ray treatment and two in the EMS treatment failed to survive after having attained 15—20 cm growth. From the mean bush volume (growth data) of the treated and control plants, it is evident that only the 0.25% EMS treatment had a mean volume higher than that of the control. The differences were significant over the control at the 5% level in the 1% EMS and 5 kr and 7.5 kr gamma ray treatments, where the growth was significantly

Table 1

Percentage of sprouting, mean growth and frequency of mutation in rose cv. Gulzar after mutagen treatments

No.	Treatment	Bud sprouting	Mean value of bush after 1 yr. (c cm)	Standard deviation	Values of t for P = 0.5	% mutation	Mutation phenotype
1.	Control	81	3430	834.322	1.960	—	
2.	EMS 0.25%	35.2	3585	1279.24	0.11	1.78	Blue striped on red base
3.	EMS 0.5%	40.16	2545	1278.08	0.69	—	—
4.	EMS 1.0%	4.2	278	194.00	16.2*	—	—
5.	5 kr	10.6	530	495.711	5.8*	12.4	Deep crimson stripes on red base
6.	7.5 kr	3.7	88	90.60	36.8*	—	—
7.	10 kr	—	—	—	—	—	—
8.	5 kr + 0.25% EMS	6	1245	1375.79	1.5	—	—

* Significant over the control at the 5% level

reduced. The growth differences were non-significant with post irradiation chemical mutagen treatment.

Frequency of different mutants and their isolation. From the data presented in Table 1 on the percentage mutation it is evident that the frequency of the blue striped "Gulzar" mutant was 1.78% after the 0.25% EMS treatment and that of the mutant having flowers with deep crimson stripes on a red base was 12.4% after the 5 kr treatment. After the combined treatment with two mutagens (irradiation + EMS) the effect was not marked either foı the frequency or for the growth of the treated buds. Although the difference in growth was significant in the 1% EMS and the 5 and 7.5 kr gamma ray treatments, neither the higher doses of EMS (0.5 and 1%) nor the 7.5 kr gamma ray treatment gave any mutation. The only other marked difference that was observed in chemical treatments with EMS and the recovery of mutation was the isolation technique utilized for it. Consequent upon the diplontic selection the mutated sector, which was too small to be detected in the first year of growth in the supposed mutant plant, could be recovered by the pruning or decapitation of the primary shoots during autumn leaving only a few of the basal buds, e.g. the buds of the first leaf circle. These buds, when thus forced to break, gave rise to new growth during the winter and showed the mutated phenotypic expression in March. In the case of the irradiated treatments the two mutated branches arose from the 3rd and 4th node of the primary shoot. The other six nodes that gave new shoots were normal in their flower characteristics.

Biochemical analysis of florachromes A and B. 0.5 g fresh petal acetone extracts from the flowers of the control Gulzar and its blue stripted mutant revealed that both florachromes A and B were present in them (see Kaicker—Pandey 1973). The optical density at 630 nm in the blue striped mutant of "Gulzar" was reduced from 0.25 (in the control) to 0.15, thereby indicating that "Gulzar" contained less florachrome A (blue pigment) than the mutant derived from it. For florachrome B the readings of optical density for the control and its mutant were 0.44 and 0.24 respectively.

Description of the interesting mutants

Deep crimson striped Gulzar. This is a mutant obtained after the 5 kr gamma ray treatment. The chief characteristic of its flower is the deep crimson stripes on the scarlet coloured base of the petals. There was no other change either in the number of petals per flower or in the number of blooms per bush. The mutant was obtained as a periclinal chimera on one shoot while the rest of the branches were normal. The mutant has been successfully maintained in the VM_2 and successive generations, by budding the eyes from the affected shoot separately elsewhere.

Blue striped "Gulzar". This is a mutant obtained after 0.25% EMS treatment (Plate 1). In the first year all the branches obtained were normal, but during the second year of growth, induced by severe heading back (3—4 inches), one of the side shoots that arose produced the striped flower. Here the mauve coloured stripes give a highly contrasting look on the deep red base of the petals. The number of petals per flower as also the number of flowers carried on the plant were not affected. This cv. has since been released as Madhosh in 1975 for commercial cultivation.

The primary effect observed for both physical and chemical mutagens was a decrease in bud take in all the treatments. The radiation treatments delayed the sprouting of the buds and the 10 kr dose of gamma rays was found to be too drastic. This is in line with our previous observations, as well as those of other workers (Swarup *et al.* 1971, Kaicker—Swarup 1972, Streitberg 1966a, b, c, 1968, Dommergues *et al.* 1967, Sparrow 1961, Gordon 1957, Bishop 1967). The rose bud at the time of irradiation is multicellular and has a definite number for initiation of nodes and flower bud. BROERTJES (1967) stated that those cultivars that are heterozygous for several colour genes mutate easily. The same is true for "Gulzar", which has a complex ancestry; one of its parents, "Prelude", has mauve coloured flowers. BROERTJES (1970) and many other workers (SWAMINATHAN 1958, NAKAJIMA 1965) have suggested that in multicellular propagules, as in vegetatively propagated plants like the rose, heading back is essential in order to restrict the effect of undesired diplontic selection. This method, when applied by use even after one year of growth, resulted in the expression of a mutated phenotype in the 0.25% EMS treatment, wherein the mutated cell essentially had a maximum chance of taking part in the formation of a shoot, which, when formed had blue striped flowers on a red base. It has been observed that the deep crimson striped mutant of "Gulzar" arose from 3rd and 4th nodes of the primary shoot after irradiation with a 5 kr dose of gamma rays. The theory propounded by KAPLAN (1953) and adopted by many workers (GROBER 1959, ZWINTZSCHER 1955, 1962, NAKAJIMA 1966, SWARUP *et al.* 1971, KAICKER—SWARUP 1972), that most of the mutations are confined to basal buds and up to the last affected leaf, has been observed to hold good in the present case as well. DERMEN (1960) suggested that the 2nd histogenic layer, L—II, from which the germ cells are originated, consists of cells having a genotype heterozygous for a dominant gene which controls the red pigmentation of young leaves and shoots. This has been supported by the work of PRATT *et al.* (1959), PRATT (1967), BROWN (1966) and SAGAWA—MEHLQUIST (1957), who have stated that when the variety is irradiated, the cell layer L—I is easily destroyed and this urges the epidermis or the tissue beneath it to substitute to cell layer L—II and then the recessive phenotype appears. SINGLETON (1954), however, is of the view that when a plant material, in which some alleles are in the heterozygous condition, is irradiated, a recessive phenotype that has been marked by the action of a dominant gene at the same locus will appear in some probability mostly as the result of the loss of a very small piece of chromosome on which the dominant gene is located. Perhaps both these factors may be responsible for the varied spectrum obtained in irradiated and chemical mutagen treatments, when applied to the same cv. "Gulzar". Knowledge of the cytological parameters of these mutants obtained from different treatments may perhaps indicate a plausible explanation for it. This view seems to be supported by the observations of SPARROW *et al.* (1963) and KONZAK *et al.* (1965), who stated that radiation and alkyl alkane sulphonates induced different mutation spectra. However, the evidence for spectrum differences would be more meaningful if the causal relationship to the action of the mutagen or a biochemical reaction of the organism could be identified.

Irradiation has been more useful than chemical mutagens in producing mutations in asexually propagated crops (NYBOM—KOCH 1965, NYBOM 1970, BOWEN 1965, MOES 1966, KAMARA—BRUNNER 1970). EMS was more effective as a mutagen on diploid cultivars of rose than on polyploids (HESLOT 1968). DOMMERGUES *et al.* (1967) used both gamma rays and EMS to obtain a number of mutants for shape of petals, flower colour, growth habit, etc. in rose cultivars of 2n, 3n and 4n origin, which are similar to our observations in the present study. The negative results obtained with higher concentrations of EMS (0.5 and 1.0%) and as a post-irradiation treatment may be due to insufficient penetration of the chemicals at a higher dose. However, it is evident that higher concentrations of EMS caused a greater proportion of physiological damage (measured as a decreased percentage sprouting of the buds, and a significant decrease in the overall growth after one year) and consequently no mutations. Recently it has been realised (MIKAELSEN *et al.* 1968, SAVIN *et al.* 1968) that, in general, by using presoaked seeds lower concentrations of EMS may be employed, thus yielding higher efficiency for a given treatment. The results on the isolation and quantitative estimation of florachrome A and B have also indicated the increase of florachrome A (blue pigments), as is visible in the EMS-induced blue striped mutant of "Gulzar".

In conclusion it may be stated that EMS possesses properties of high mutagenic effectiveness on rose. There is perhaps a greater need to work on the methodology of application that may make chemical mutagens more effective for asexually propagated plants, as well as on methods for the reduction of diplontic selection and for obtaining mutated sectors which could be easily spotted.

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EFFECTS OF RECURRENT BORO (DRY) SEASON PLANTINC ON HEREDITARY CONVERSION OF AMAN RICE

Among the three traditional groups of rice, viz. aus (autumn), aman (winter) and boro (summer), grown in West Bengal, the aman varieties have been found to flower regularly when the day length is between 11.8 and 12.5 hours during the boro season exhibiting optimum growth and yield. The increased yield during the boro season is largely attributed to the higher intensity and duration of sunlight (Das Gupta 1974, De Datta—Zarate 1970) and to the greater adaptability of aman varieties under the climatic conditions of the season. It has been estimated that the daily solar energy available in the tropics during the boro season is approximately 550—600 g cal cm^{-2} day^{-1} as against 300—350 g cm^{-2} day^{-1} during the kharif season, which is characterised by cloudy monsoon weather. These facts thus indicate the possibility of increasing the yield of quality grains in the country by adopting the large scale cultivation of aman varieties during the boro season with assured irrigation.

This aspect has unfortunately been neglected for a long time owing to the prevalent practice of growing rice during the boro season only on very limited areas, and then, too, other than aman varieties. Lack of appreciation of the possibility of selecting suitable aman cultivars, and of determining the optimum planting time and the requisite input and management factors tempered to the boro condition of culture have constituted the constraints in this regard despite the fact that several observations of good performance by quite a number of aman varieties during the boro season have been reported.

The first object of the studies reported herein has, therefore, been to assess the performance and analyse the behaviour of a number of aman varieties, which were subjected to early and late plantings in the boro season. Recurrent planting on the fixed dates for four consecutive years from 1967 to 1970 brought forth an interesting result. Delayed planting (i.e. in February) caused a shortening of about 40 days in the duration of flowering and maturing. This phenomenon was very clearly discernible in two of the four aman varieties studied.

Considering the gradual shortening of flowering duration in the progeny of the succeeding years in some aman varieties, it seems logical to presume that the climatic conditions of the late, i.e. February planting, whether those prevalent at sowing or from planting to maturity, might have caused some metabolic changes in the seeds (Rajki *et al.* 1972) resulting in better adaption and early maturity under the climatic conditions of the late boro season. Even as early as in 1868, the great evolutionary biologist Darwin suggested that environmental changes affecting body tissues during their development result in the formation of changed gemmules or sexual elements. If this is so, then such aman varieties, which have shown significant earliness in maturity, presumably in response to some natural climatic treatment at some growth phase or the other during the late boro season, ought to express a similar reaction even during a different season, if the quality and quantity of the environment specific for the phenomenon were to prevail. Rajki *et al.* (1972) suggested that the living body requires for its various physiological processes, and for the formation of its various organs, those environmental conditions from which the analogous processes and organs developed in previous generations.

With the above background in view the seeds of one such aman variety (Nagra 41/14) from the February planting were grown for four consecutive years (1967—68 to 1970—71) in the late boro season, and then brought into the kharif season of 1971 which followed immediately, along with the seeds of the same variety from the previous (1970) kharif harvest, and the reaction of the plants from these two sets of seeds were critically studied in terms of growth, flowering and yield as the second object in these studies.

There were two series of experiments conducted at the Rice Research Station, Chinsurah (West Bengal).

Table 1

Effect of date of planting on days to flower and duration

Variety	Date						
	December 15th					January	
	1967–68	1968–69	1969–70	1970–71	Mean	1967–68	1968–69
							(a) *Days*
Latisail	150	151	152	150	151	130	128
S. R. 26B	151	151	150	150	151	131	133
Indrasail	150	148	148	149	149	134	136
Nagra 41/14	155	155	154	154	155	140	139
Mean	152	151	151	151		134	134

C. D. at 5% P: Variety = 1.53, Date of planting = 1.32, Variety × Date of planting = = 2.65

							(b) *Duration*
Latisail	180	181	180	179	180	160	159
S. R. 26B	180	179	177	181	179	160	163
Indrasail	180	179	178	178	179	164	165
Nagra 41/14	183	184	184	182	183	168	177
Mean	181	181	180	180		163	164

C. D. at 5% P: Variety = 1.60, Date of planting = 1.38, Variety × Date of planting = = 2.76

Series I. The experiment was conducted for four consecutive years during the boro season from 1967–68 to 1970–71. Altogether four varieties, viz. Latisail, S. R. 26B, Indrasail and Nagra 41/14, were employed in the study.

Sprouted seeds of each variety were sown in sed beds on three planting dates, viz. on the first day of November, December and January each year. During the four years of experimentation successive seed generations of each variety were always raised in an unaltered sowing time environment. The different varieties from each planting date were allotted to individual non-replicated plots (10.5 m × 1.8 m) at random. On each unit plot, 45-day-old seedlings were transplanted in rows 22.8 cm apart on 15th December, 15th January and 15th February, using one healthy seedling per hill. Ear emergence, when more than 50% of the plants had flowered, was noted for each variety. Duration (50% plant maturity) was similarly scored. Yield data were taken after thorough drying of the grains in the sun. For this purpose the mean of 20 plants selected at random from each of the varieties for each planting date was taken into consideration. Data on the average maximum and minimum temperature, bright sunshine hours, percentage humidity and total rainfall during the seasons were collected from the meteorological unit of the Research Station.

Series II. The experiment was conducted for three consecutive years in the kharif season of 1971–1973 employing the variety Nagra 41/14 which had showed a gradual reduction in flowering duration and an improvement in yield in the late boro season (February planting) *of the aman varieties during the boro (dry) season*

of planting							
15th			February 15th				
1969–70	1970–71	Mean	1967–68	1968–69	1969–70	1970–71	Mean
to flower							
131	133	131	110	108	107	113	110
131	135	133	108	112	114	115	112
134	135	135	114	108	109	113	111
141	142	141	114	110	108	110	111
134	136		112	110	110	113	
in days							
160	161	160	142	139	139	145	141
160	164	162	140	145	145	146	143
162	164	164	144	139	141	140	141
169	170	169	145	140	137	139	140
163	165		143	140	141	143	

during the previous years of experimentation under Series I. The seeds of the boro harvest from the February planting of 1970—71, along with the seeds of the same variety from the previous kharif harvest (1970), were used for raising the two sets of experimental populations in the first year (1971, kharif). During the subsequent two years of experimentation (kharif, 1972 and 1973), the seeds collected from the plants of earlier boro harvested seeds and the seeds collected from the plants of the previous kharif descent only were used for raising the population of the set designated as kharif harvested seeds.

The experiment was conducted in a randomized block design with three replications. The net size of the unit plot was 5×3 m. 25-day-old healthy seedlings (sown on June 12th every year) were transplanted every year on July 7th with a spacing of 20×15 cm, using two seedlings per hill. Data were collected on flowering and maturity duration (based on observation on 50% plants per plot), and on grain yield and productivity (based on 10 plants per plot per replication). Data on climatic factors were collected from the meteorological unit of the Station.

Series I results. Irrespective of the variety, the time required from sowing to flowering decreased linearly as the date of planting was delayed from December to February (Table 1). Thus, amongst the three dates of planting, significantly earlier flowering was noted in the February 15th planting and latest in the December 15th planting (Fig. 1). Amongst the different varieties, flowering was noted earliest in Indrasail in the December planting, and in Latisail

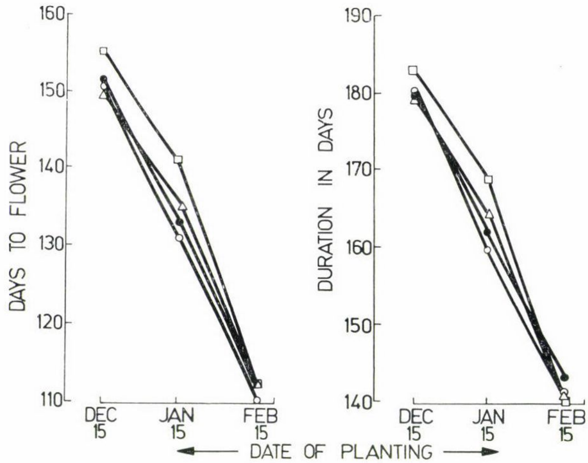

Fig. 1. Effect of date of planting on days to flower and duration of the rice varieties during the *boro* season (Latisail: Open circles, S. R. 26B: Solid circles, Indrasail: Open triangles, Nagra 41/14: Solid triangles)

Table 2

Percentage of flowering in the February 15th planting

Variety	1967–68	1968–69	1969–70	1970–71	Mean
Latisail	51	33	51	11	36.5
S. R. 26B	44	5	26	5	20.0
Indrasail	5	29	92	88	53.5
Nagra 41/14	5	30	56	100	47.8

Table 3

Analysis of variance

Source of variation	D. F.	Days to flower		Duration in days	
		M. S. S.	F. value	M. S. S.	F. value
Year	3	7.01	2.06 NS	5.17	1.40 NS
Variety	3	52.67	15.49**	29.17	7.88*
Date of planting	2	6588.16	1937.69**	6081.51	1643.65**
Variety × Date of planting	6	24.59	7.23**	23.81	6.44*
Error	33	3.40		3.70	

* Significant at 5% level
** Significant at 1% level
NS Not significant

in the January and February planting. It should, however, be noted that flowering of the aman varieties in the February planting was very scanty and erratic (Table 2), but in two of the varieties, namely Indrasail and Nagra 41/14, the flowering gradually improved after continuous planting for four consecutive years. The effect of variety, date of planting and the interaction between the two was highly significant with respect to flowering (Table 3).

Both the dates of planting and varieties produced significant effects on the grain yield during all four years of experimentation (Tables 4, 5 and Fig. 2). In all the varieties, maximum yield was attained in the December planting and then declined sharply as planting was delayed up to February 15th. The significantly low yield during the February planting is attributed to irregular and scanty flowering in all the aman varieties, particularly during the early years. While analysing the relative performances of the different varieties, it was noted that Latisail gave the highest yield during the December and January plantings but in the February planting a greater yield was obtained in Nagra 41/14. It appears from the results that rice varieties responded to dates of planting at a significant level (Table 5). In general, the rate of productivity was highest in the December planting and sharply declined as the date of planting was delayed, giving the lowest values in the February planting (Table 4, Fig. 2). Amongst the varieties the highest rate of productivity was recorded in Nagra 41/14, irrespective of the date of planting. The variation due to year and date of planting was found to be significant in this respect (Table 5).

Series II results. It is evident from the results (Table 6) that the boro and kharif harvested seeds of the aman variety Nagra 41/14 produced a significant difference with respect to days to flower, maturity and productivity, when grown during the subsequent kharif seasons. Variation due to the year, however, was not significant with respect to any of the properties except productivity. The relatively higher productivity obtained with the boro harvested seeds, despite the slightly lower yield, resulted mainly from decreased duration in the kharif season.

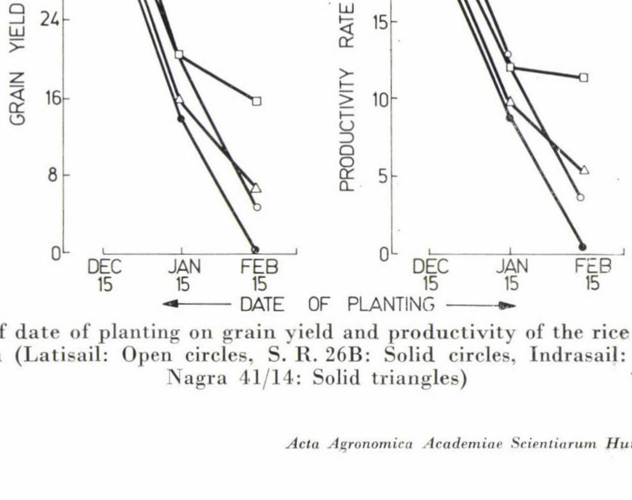

Fig. 2. Effect of date of planting on grain yield and productivity of the rice varieties during the boro season (Latisail: Open circles, S. R. 26B: Solid circles, Indrasail: Open triangles, Nagra 41/14: Solid triangles)

Table 4

Effect of date of planting on grain yield and production

Variety	Date						
	December 15th					January	
	1967–68	1968–69	1969–70	1970–71	Mean	1967–68	1968–69
						(a) *Grain yield*	
Latisail	46.4	45.8	34.5	50.0	44.2	8.3	14.9
S. R. 26B	38.7	40.5	26.8	41.7	36.9	8.9	10.7
Indrasail	41.7	32.1	41.1	38.7	38.4	11.3	12.5
Nagra 41/14	51.8	32.9	30.4	47.6	40.7	6.0	11.9
Mean	44.7	37.8	33.1	44.5		8.6	12.5
						(b) *Productivity*	
Latisail	25.8	25.3	19.2	27.9	24.6	5.2	9.4
S_6 R. 26B	21.5	22.6	15.1	23.0	20.6	5.6	6.6
Indrasail	23.2	17.9	23.1	21.7	21.5	6.9	7.6
Nagra $41_8 14$	28.3	17.9	16.5	26.2	22.2	3.6	7.1
Mean	24.7	20.9	18.5	24.7		5.3	7.7

C. D. at 5% P: Variety = 0.66, Date of planting = 0.57, Variety × Date of planting = 1.14 (grain yield)

C. D. at 5% P: Variety = 4.32, Date of planting = 4.74, Variety × Date of planting = 7.50 (productivity)

The most interesting feature of the investigation in this series was the perpetuation of significant earliness in flowering and maturity of the boro harvested seeds (from the February 15th planting) compared to the kharif harvested seeds during all three years of experimentation (Table 6). Recalling the results of Series I, it may be noted that the February 15th planting in the boro season induced significant earliness and maturity in the plants compared to those of either the December or the January plantings during all the previous four years of experimentation (1967–68 to 1970–71).

There are two aspects of the basic problem of maximization of production in Indian rice agriculture: (i) the shortening of the duration of the aman varieties during their traditional kharif season of culture, and (ii) the adoption of large scale cultivation of aman varieties under a new climatic situation during the boro season. Essentially these call for, among other things, the selection of suitable varieties, the determination of the optimum time of planting and the application of proper fertilizer doses. The results of a few previous experiments (Choudhury–Ghosh 1966, De Datta–Zarate 1970, Das Gupta 1974, and others), including those of the present authors, have helped in recognizing the possibility of the aman group of rices flowering during the boro season of culture and have also made possible the identification of a good number of aman varieties that show such a potentiality during the boro season. However, the question of the selection of suitable aman varities for boro culture and the extent of their *of the aman varieties during the boro season*

of planting							
15th			February 15th				
1969–70	1970–71	Mean	1967–68	1968–69	1969–70	1970–71	Mean
(q/ha)							
27.4	31.5	20.5	3.0	0.40	16.1	0.06	4.9
22.0	14.3	14.0	1.5	0.04	0.1	0.02	0.4
19.6	20.2	15.9	0.4	2.40	7.1	17.90	7.0
26.2	36.9	20.3	0.4	1.10	24.4	35.70	15.4
23.8	25.7		1.3	0.99	11.9	13.42	
rate (kg/ha/day)							
17.1	19.6	12.8	2.10	0.30	11.60	0.04	3.51
13.8	8.7	8.7	1.10	0.03	0.10	0.01	0.31
12.1	12.3	9.7	0.30	1.70	5.00	12.80	4.95
15.5	21.7	12.0	0.30	0.80	17.80	25.70	11.15
14.6	15.6		0.95	0.71	8.63	9.64	

Table 5

Analysis of variance

Source of variation	D. F.	Grain yield		Productivity rate	
		M. S. S.	F. value	M. S. S.	F. value
Year	3	3.26	5.17**	124.75	4.59**
Variety	3	1.89	3.00*	51.08	2.25 NS
Date of planting	2	46.21	73.35**	1227.63	45.22**
Variety × Date of planting	6	0.26	0.41 NS	24.10	0.89 NS
Error	33	0.63		27.15	

* Significant at 5% level
** Significant at 1% level
NS Not significant

Table 6

Effect of boro and kharif harvested seeds on flowering, duration, yield and productivity of the aman variety Nagra 41/14 during the kharif seasons of 1971—73

Year	Days to flower		Duration in days		Grain yield q/ha		Productivity rate (kg/ha/day)	
	Boro	Kharif	Boro	Kharif	Boro	Kharif	Boro	Kharif
1971	93	132	121	162	20.2	21.8	16.7	13.4
1972	93	135	122	164	19.2	20.7	15.8	12.6
1973	94	134	123	163	16.9	18.9	13.8	11.6
Mean	93	134	122	163	18.8	20.5	15.4	12.5
C. D. at 5% P for source of seed	1.29		1.32		0.16		1.07	

Analysis of variance table

Source of variation	D. F.	Days to flower		Duration		Grain yield		Productivity	
		M. S. S.	F. value	M. S. S.	F. value	M. .S. S.	F. value	M. S. S.	F. value
Block	2	0.39	0.26 NS	1.17	0.75 NS	0.069	2.88 NS	3.13	2.98 NS
Year	2	1.39	0.91 NS	2.17	1.38 NS	0.153	6.38*	8.39	8.00**
Source of seed	1	7320.50	48.1612**	7646.72	4870.52**	0.123	5.13*	38.13	36.31**
Year × source of seed	2	3.50	2.30 NS	0.73	0.47 NS	0.002	0.08 NS	0.47	0.45 NS
Error	10	1.52		1.57		0.024		1.05	

* Significant at 5% level
** Significant at 1% level
NS Not significant

response in terms of duration and yield under varied planting dates during the boro season has yet remained unresolved.

Viewed in this context, the results of the investigations in Series I present certain broad trends with respect to flowering and yield.

In the December 15th and January 15th plantings none of the aman varieties showed noticeable irregularity with respect to flowering. This seems, therefore, to suggest full ecological establishment of the aman varieties under the growing conditions of the early boro season. However, during the February 15th planting a significant irregularity in flowering with sterile grains leading to decreased yield and productivity was noted. These results notwithstanding, in at least two of the four aman varieties, namely Indrasail and Nagra 41/14, flowering radually improved, resulting in a proportional increase in yield in the succeeding years. It is thus evident that even the short day sensitive aman varieties may be made to flower and produce a satisfactory yield under the unfavourable environmental conditions of the February planting by means of continuous cultivation over a number of years. The present findings may thus be indicative of the fact that rice varieties could slowly be acclimatised to conditions other than their normal conditions, as all are almost certainly of the same origin and have in the course of time become specially adapted to their particular environment.

The significant shortening in the time from sowing to flowering and maturity (duration) under delayed planting poses rather an interesting problem. It was observed that in all four aman varieties the time required from sowing to flowering or maturity decreased linearly as the date of planting was delayed from December to February. Although delayed planting, particularly the February 15th planting, produced a very low yield of grains, the results undoubtedly indicate the possibility of gradual establishment of at least some of the aman varieties under the growing conditions of the late boro season as early maturing strains.

The next pertinent question that was probed was whether such an earliness in duration of the aman varieties, perpetually expressed in four successive late boro season sowings, could be regarded as the hereditary transformation of an acquired character. And, in this regard, it is very interesting to note that the results obtained in the second experimental series conducted successively over a period of three years provided a clearly affirmative answer. The trait in question was similarly expressed even under the different environmental conditions of the kharif season. Darwin (1909) stated that, under certain conditions, organisms may slightly alter their existing characteristics during ontogeny and several of the properties thus acquired are inherited by their progeny. Thus, the decreased duration of the aman variety Nagra 41/14 in the kharif season, which was lacking in the initial parent seed, and which developed as a result of the changed environment of the late boro season (in the February 15th planting), may be interpreted in terms of the inheritance of acquired characteristics (Rajki *et al.* 1972). Darwin (1868) also strongly suggested that the inheritance of acquired characteristics is obviously possible.

Two questions emerge from the results of the two successive series of experiments. Firstly, what factor or factors are responsible for the marked earliness in maturity of plants of aman varities during the February 15th planting? And, secondly, what is the fundamental basis of the significantly early growth duration of the boro harvested seeds compared to the kharif harvested seeds?

In this connection it may be of great relevance to examine the results of both series critically in terms of interaction between the average temperature and day length of the growth duration, or in terms of what are commonly known as "phenological" records (Nuttonson 1948).

An in-depth study of the phenological records (Table 7) compiled during the experimental period of Series I evidently shows that although the rice plants varied quite significantly with respect to flowering and duration due to the change in the date of planting, the

Table 7

Phenology of aman rice during the boro (dry) season (Records covering the experimental period under Series I)

Date of sowing	Date of planting	Year	Date of 50% flowering	Date of maturity	From planting to maturity: Days	Day-degrees (°C)	Average length of day (hrs)	Average lenght of day multiplied by day-degrees
Nov. 1st	Dec. 15th	1967—68	1. 4. 68.	30.4.68.	137	3120	11.38	35,505
		1968—69	31.3.69.	30.4.69.	137	3127	11.38	35,585
		1969—70	31.3.70.	29.4.70.	136	2992	11.38	34,049
		1970—71	31.3.71.	29.4.71.	136	2995	11.38	34,081
		Mean	31.3.	30.4.	137	3059	11.38	34,805
Dec. 1st	Jan. 15th	1967—68	13.4.68.	12.5.68.	118	2909	11.88	34,554
		1968—69	13.4.69.	13.5.69.	119	2947	11.88	35,010
		1969—70	13.4.70.	12.5.70.	118	2847	11.88	33,822
		1970—71	15.4.71.	14.5.71.	120	2891	11.88	34,339
		Mean	14.4.	13.5.	119	2899	11.88	34,432
Jan. 1st	Feb. 15th	1967—68	22.4.68.	23.5.68.	98	2720	12.22	33,238
		1968—69	20.4.69.	20.5.69.	95	2582	12.22	31,552
		1969—70	20.4.70.	21.5.70.	96	2538	12.22	31,014
		1970—71	23.4.71.	23.5.71.	98	2559	12.22	31,265
		Mean	21.4.	22.5.	97	2600	12.22	31,767

(a) The summation of day-degrees consists of the summation of all mean daily temperatures above 0°C (Nuttonson 1948)

flowering occurred at an almost constant multiple of the average length of day and the summation of total day degrees. Thus, the duration of rice varieties appears to be associated with a response to more than one environmental factor, namely, to a combination of the average length of day and the summation of day degrees. It appears, therefore, that the temperature must be taken into account in studies dealing with the relation of rice varieties to length of day. As may be observed in the table, the stage of 50% flowering on March 31st of the December 15th planting can be interpreted as having been brought about by a combination of 3,059 day degrees and 11.38 hours of average daylight, while in the case of the February 15th planting the same stage occurring on April 21st appears to have been brought about by a combination of 2,600 day degrees and 12.22 hours of average daylight. Thus, it may be suggested that the flowering of aman rices is brought about by a combination of either a relatively higher summation of day degrees and shorter days or by a relatively lower summation of day degrees and relatively longer days. In other words, irrespective of the date of planting, flowering in the rice varieties seems to occur under a number of combinations of temperature and daylength conditions. NUTTONSON (1948) also observed in Marquis wheat that blossoming or heading in

Table 8

Phenology of the boro and kharif harvested seeds of the aman variety Nagra 41/14 during the kharif seasons of different years (Records covering the experimental period under Series II)

Source of seed	Date of sowing	Date of planting	Year	Date of 50% flowering	Date of maturity	From planting to maturity			
						Days	Day-degrees (°C)	Average length of day (hrs)	Average length of day multiplied by day-degrees
Boro (1970—1971)	June 12th	July 7th	1971	11.9.71.	9.10.71.	95	2656	12.47	33,120
			1972	13.9.72.	12.10.72.	97	2793	12.47	34,829
			1973	14.9.73.	13.10.73.	98	2780	12.45	34,611
			Mean	13.9.	11.10.	97	2743	12.46	34,187
Kharif (1970)	June 12th	July 7th	1971	22.10.71.	22.11.71.	138	3721	12.12	45,099
			1972	25.10.72.	23.11.72.	141	3834	12.12	46,468
			1973	24.10.73.	22.11.73.	140	3759	12.12	45,559
			Mean	24.10.	22.11.	140	3771	12.12	45,709

some varieties appears to be associated with a response to more than one environmental factor, namely, to a joint effect of the average length of day and the summation of day degrees in the vegetative stage.

Again, linking the phenological records (Table 8) with the results obtained in Series II, it becomes evident that although the boro harvested and kharif harvested seeds of the aman variety Nagra 41/14 were of the same basic genotype, the earliness in duration occurred only in the boro harvested seeds, which received almost an identical multiple of the average length of day and the summation of total day degrees during the kharif season as that of the previous late boro season (in the February 15th planting). The average values of the multiple of day length and day degrees in the boro and kharif seasons were respectively 31,767 (Table 7) and 34,187 (Table 8). On the other hand, the kharif harvested seeds had a requirement of 45,709 units of this multiple from planting to maturity. Thus, agreeing with the views of RAJKI *et al.* (1972), it may be concluded that also in rice the inheritance of acquired characteristics is possible even under a different seasonal environment, provided that those environmental conditions from which the analogous processes developed in previous generations exist. Under the influence of a change in the quality and quantity of the environment as prevalent during the late boro season (in the February 15th planting), the medium maturing (163 days) aman variety Nagra 41/14 was thus transformed into an early maturing (122 days) variety.

Nevertheless, the above conclusion must remain tentative till the role of phenology on the flowering and maturity of aman varities of rice is critically studied under controlled conditions of day length and temperature.

Whatever the fundamental basis may be, however, the fact remains that it is possible to reduce the growth duration of the aman varieties of rice, which are normally grown extensively during the kharif season in preference to other varieties, by the influence of the environmental conditions of the late boro season (in the February 15th planting), and that it is also possible to reproduce this acquired characteristic in the kharif season. This method of shortening the duration of aman varieties, which still contribute nearly 90% of quality grains in the country, may indeed serve as a unique tool with regard to the multiple cropping system characteristic of progressive agriculture.

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ENDOGENOUS GIBBERELLIN AND AUXIN LEVELS IN MALE STERILE SUNFLOWERS PRODUCED BY HORMONE TREATMENT

One of the crucial problems of hybrid sunflower breeding is how to produce male sterile flowers. One of the best practical methods is the application of chemicals. Results of experiments of this type are hardly found in the literature. Of the sporadic data the works of Schuster (1961, 1963, 1969) and Klimov (1971) should be mentioned.

In an earlier publication (Frank—Köves 1976) an account was given of an experiment in which hormone treatments were used to induce male sterility. The present work presents the results of analyses related to hormone treatments aimed at inducing male sterility, carried out to obtain information about the hormonal regulatory system of male sterility. In the course of the experiments the endogenous IAA and GA contents in the shoot apex of sunflower plants were determined after various hormone treatments. By comparing the changes in the hormone

Table 1

Changes in the endogenous IAA level in sunflower shoot apex treated with IAA and GA

Treatment	Marking of samples, date of sampling							
	I (13. 6.)		II (15. 6.)		III (17. 6.)		IV (19. 6.)	
	μg IAA per 100 g	male sterility, %	μg IAA per 100 g	male sterility, %	μg IAA per 100 g	male sterility, %	μg IAA per 100 g	male sterility, %
1. Control	1.12	—	1.86	—	1.81	—	0.74	—
2. IAA 0.01%	2.98	—	2.09	—	0.85	—	0.37	—
3. IAA 0.005%	2.70	—	1.45	—	0.23	—	0.07	—
4. IAA 0.001%	20.90	—	8.80	—	1.99	—	0.21	—
5. GA 0.033%	0.59*	62.5*	0.79	40	1.06	100	0.05	82
6. GA 0.016%	0.43*	—*	1.2	44	1.75	75	1.39	63.9
7. GA 0.0033%	2.70*	12.5*	9.60	—	1.42	12	0.24	18.2

*The active substance is generally pipetted onto the shoot tip, but injected in treatments marked

level with the extent of male sterility in the treated plants conclusions were reached concerning the hormonal factors inducing male sterility and protogynia.

In outdoor experiments the shoot tips of 33, 35, 37 and 39-day-old plants of the *Helianthus annuus* variety WNIIMK 6540 were treated with 0.01, 0.005 and 0.001% solutions of indole-3-acetic acid (Merck preparation), and with 0.033, 0.016 and 0.0033% solutions of gibberellic acid (Phylaxia product). Samples were taken on the third day after each treatment. Samples taken on four successive occasions were marked I—IV, corresponding to the following dates of sampling: I = 13.6.1975, II = 15.6.1975, III = 17.6.1975, IV = 19.6.1975.

Two methods of treatment were employed: the solutions were either applied by pipette or injected. Samples were taken after each treatment on the third day. The sample included the apical bud and the surrounding uppermost circle of leaves.

A fresh weight of 1 g material was used for each IAA and GA determination. Extraction was carried out with cold methanol. The extract was subjected to paper chromatography in a 10 : 1 : 1 mixture of iso-propanol—ammonia—water, and the quantity of IAA in the chromatogram spot was determined by the method of Hancock—Barlow (1952) and Bentley—Housley (1954) on the basis of the growth reaction given by *Avena* coleoptilesegments.

After separation by thin layer chromatography (Reinhard *et al.* 1964) the GA was determined from a methanol extract by ethyl acetate fractionation, with the aid of a barley endosperm test (Jones—Varner 1967).

Other circumstances and procedures connected with the setting up of the outdoor experiments were described in our previous paper (Frank—Köves 1976).

1. Changes in the endogenous IAA level in the shoot apex of sunflower treated with IAA and GA. The data contained in Table 1 show the following correlations.

During the period examined the IAA content of the control as referred to the fresh weight first increased, then remained more or less constant, and finally — at the fourth date of sampling — decreased. This tendency corresponds to the change with time in the IAA content of other similar materials.

Table 2

Changes in the endogenous gibberellin level in sunflower shoot apex treated with IAA and GA*

Treatment	Marking of samples, date of sampling							
	I (13. 6.)		II (15. 6.)		III (17. 6.)		IV (19. 6.)	
	μg IAA per 100 g	male sterility, %	μg IAA per 100 g	male sterility, %	μg IAA per 100 g	male sterility, %	μg IAA per 100 g	male sterility, %
1. Control	2.9	—	2.1	—	1.6	—	1.2	—
2. IAA 0.01%	—	—	—	—	2.1	—	1.9	—
3. IAA 0.005%	—	—	—	—	1.2	—	1.6	—
4. IAA 0.001%	—	—	—	—	1.8	—	2.0	—
5. GA 0.033%	5.0	67	3.8	40	1.6	100	1.2	82
6. GA 0.016%	9.6	28	6.0	44	6.2	75	2.1	64
7. GA 0.0033%	12.6	10	8.4	—	8.8	12.5	2.6	18

The active substance was pipetted onto the shoot apex in every case
* In GA_3 equivalent

In samples taken on the first two occasions, with the exception of a single sample, the endogenous IAA level measured on the third day after IAA treatment increased in all concentrations compared to the control. At the third and fourth sampling, again with the exception of one sample, the IAA content decreased compared to the control.

The decrease is probably due to the fact that the metabolism of the meristem in the shoot apex becomes more intensive during this period of ontogenesis. Consequently, while in the case of the first treatment a considerable proportion of the exogenous IAA remained unchanged until the sampling, with the later treatments it became fully metabolized during the same two day period. It is highly probable that in the meristem many enzymes including IAA-oxidase become activized, possibly by means of substrate induction by IAA.

In the case of samples I and II in Table 1 the very high IAA content obtained with the 0.001% IAA treatment can be explained by the very slow IAA metabolism in this development stage and with this IAA concentration.

The highest concentration GA treatment (0.033%) — which is also the most effective concentration from the point of view of inducing male sterility — decreased the endogenous IAA level compared to the control, while the lowest GA concentration (0.0033%) increased it in samples I and II. The latter result is in agreement with many literary data published by Galston (1959), Housley—Deverall (1961), Pilet—Wurgler (1958), Stutz—Watanabe (1957) and in connection with other materials. According to these authors the increase in the IAA level in plants treated with GA is based on an IAA-oxidase inhibition caused by the GA.

In the case of low GA concentrations the GA-induced increase in the IAA level could also proceed via an increase in the biosynthesis of IAA due to the decarboxylation of tryptophane. Such experimental results were published by Kurashi—Muir (1962), Nitsch (1957) and Philips *et al.* (1959), who demonstrated that in various materials it was through the formation of IAA from tryptophane that GA caused an increase in the IAA level.

Since, judging by the size of the sunflower heads, the 0.033% GA may be considered to be above the optimum (FRANK—KÖVES 1976), some mechanism other than the change in the activity of IAA-oxidase is probably responsible for the disappearance of the IAA.

2. Changes in the endogenous gibberellin level in sunflower shoot apex treated with IAA and GA. As shown by the data of Table 2 the endogenous gibberellin content of the control displays a tendency to decrease in samples, i.e. at dates, I—IV. The effect exerted by the exogenous IAA on the endogenous gibberellin level is only known for samples III and IV.* In these cases the IAA treatment caused no substantial changes in the endogenous gibberellin content compared to the control.

The results show that the GA concentration most efficient in increasing the endogenous GA level is 0.0033%, while that inducing the greatest extent of male sterility is one order of magnitude higher.

The most remarkable increase in the endogenous gibberellin content was found in sample I, measured on the third day after the treatment, though in most cases even in the later treatments the endogenous gibberellin content was higher than in the control.

A comparison of the data of the two tables shows that the IAA treatment did not significantly influence the GA content, and male sterility was not induced by it at all. On the other hand, GA applied at a concentration causing a considerable extent of male sterility generally decreases the IAA content and increases or leaves unchanged the GA level measured on the third day after the treatment. The latter level is not proportional to the percentage of male sterility induced by it.

It can be established that the induction of male sterility does not require a permanently high hormone content, and that the high endogenous GA level is in itself no basis for male sterility. Although the investigations have given no answer to the question of when the increase caused by the treatments in the levels of IAA and GA reaches a maximum, they have nevertheless thrown some light on the fact that in samples taken at various times the course of changes in the hormone contents was not uniform, since in samples III and IV, as mentioned above, the metabolization of IAA, and probably of GA too, was more rapid than in samples I and II. This is why it was possible for the highest degree of male sterility to be found in a sample with a GA content similar to that of the control. These facts lead to the conclusion that the hormone level inducing male sterility developed before the samples were taken at a critical, relatively high GA and low IAA level, judging by the tendencies which reflect a slower GA and faster IAA metabolism.

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EFFECT OF THE SOURCE OF SOME MICROELEMENTS ON THE STORAGE QUALITY FEATURES OF FRUITS DEVELOPED ON TOMATO (LYCOPERSICUM ESCULENTUM MILL.) PLANTS GROWN IN CALCAREOUS SOIL

The tomato is by far the most important crop among the vegetables grown in the ARE Besides its demand as a favourite vegetable and for the canning industry, it represents an important commodity to foreign markets. For this reason and due to the increased population of Egypt, studies on this crop are very necessary particularly on new cultivated areas, one of which is the North Western Region, the soils of which are calcareous and which occupies more than 121,500 hectares.

The main characteristic of such soils is the high content of $CaCO_3$. Several agricultural problems such as micronutrient deficiencies and lime-induced chlorosis are associated with the presence of a certain amount of calcium carbonate.

The aim of this study was to overcome the nutritional problems concerned with micronutrients by using a foliar spray with some microelements in the form of chelated compounds or minerals.

To complete the picture of tomato development, the quality features of tomato fruits during storage were studied.

A completely randomized design with four replicates was carried out as a summer planting in the Northern Section of El-Tahrir Province. The soil was ploughed and ridged 100 cm

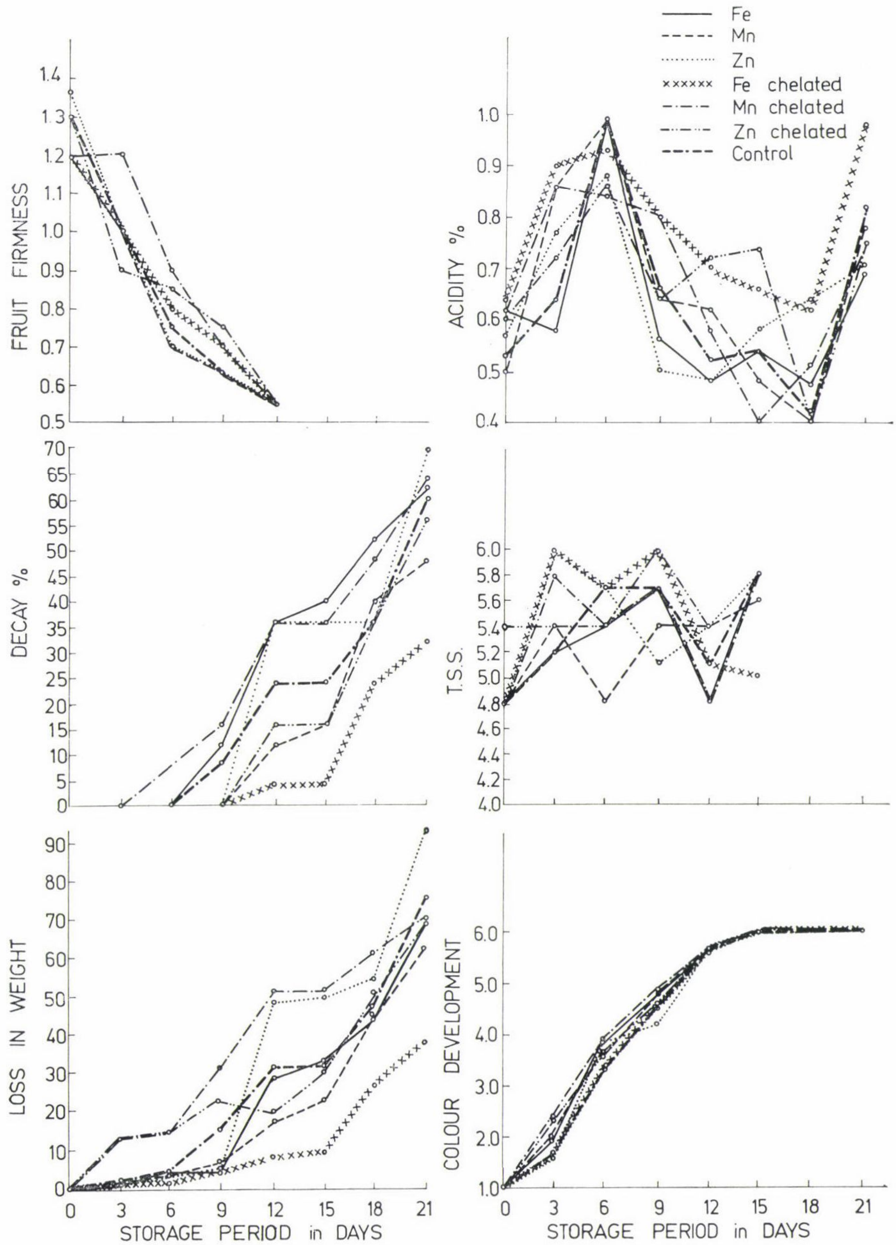

Fig. 1. Effect of the source of some microelements on the tested storage features of tomato fruits

apart. N, P and K fertilizers were used at the obvious rates twice, i.e. four weeks after transplanting and at the start of fruit setting.

The evaluation was carried out for Fe, Mn and Zn, which were foliar-sprayed at concentrations of 0.25%, 0.20% and 0.15% respectively, and the same elements in the chelated form, EDDHA-NaFe, EDTA-Na_2Mn and EDDHA-Na_2Zn at concentrations of 0.15%, 0.12% and 0.15% respectively before flowering. Tomato fruit samples were picked from the field at tha mature green stage, placed in small boxes and stored at room temperature (25°C). Fruit samples were tested periodically, every 3 days.

The data were recorded as follows

Fruit firmness. This was estimated according to WALLY—EL-NABAWY (1967).

Decay per cent. Decayed and shrunken tomato fruits were discarded and calculated as a percentage.

Colour development. Fruits were tested for ripeness periodically, every 3 days, based on colour development. The numerical scores assigned to ripeness classes were: Mature green (1), breaker (2), light pink (3), dark pink (4), table ripe (5) and canning ripe (6).

The scores of the individual fruits were averaged at each sorting to obtain a ripeness score of each sample (ABDEL-KADER *et al.* 1968). Sorting continued until 50% or more of the original sample was discarded.

Loss in weight. This was determined by weighing a collective sample of 25 fruits of uniform size and the sample was weighed periodically every 3 days. Decayed and shrunken tomato fruits were discarded and calculated as a percentage.

Total soluble solids. This was determined using a Zeiss Refractometer.

Total acidity. The acidity was determined by titration according to EL-BARKOUKI (1958).

The experiment was repeated twice and the average results of the two experiments are presented.

The data obtained as represented in the figure show the quality features of tomato fruits as affected by the forms of certain microelements, i.e. Fe, Mn and Zn. Except for a few discrepancies the results revealed a lower decay percentage for fruits developed on plants sprayed with chelated Fe, Zn or Mn. Moreover, Mn and chelated Fe, Zn slowed down the decay when it started after 9 days, as compared with other treatments, i.e. Fe, control and chelated Mn, when decay started after a 6 day storage period. This may be due to the fact that microelements, especially in the chelated form, improve the quality of the fruits, as explained by JOHN *et al.* (1958).

Tomato fruits developed on plants sprayed with chelated Fe seemed to be the best of all the treatments as regards the percentage loss in weight during storage. However, the loss in weight increased as the storage time increased, confirming the results obtained by RADWAN *et al.* (1965).

Concerning the firmness of the tomato fruits, it may be seen in the figure that the chelated microelements Fe, Mn and Zn led to an improvement in this characteristic during storage compared to treatment in the mineral form. Generally, there was a gradual decrease in the firmness of the fruits until the end of the storage period. This phenomena may be attributed to the enzymatic activity of "pectinase enzyme", which has been found to gradually reduce the level of calcium pectate in the middle lamella, which binds the cell walls of the tissues (BONNER 1950 and MAYER—ANDERSON 1952).

With respect to colour development, the results revealed that neither form of micronutrients affected it clearly. The tomato fruits began to change colour to ripeness up to 15 days, and then became constant until the end of the storage period.

When the total soluble solids were compared, it was found that spraying the plants with the chelated forms of Fe, Mn and Zn gave higher values compared with the mineral microelements, confirming results obtained by JOHN *et al.* (1958). This may be attributed to the functions of the microelements, especially in the chelated form, which take place more readily in the metabolic activities in the synthesis of carbohydrates and proteins (SHKOLNIK—ADURASBITOV 1958); these microelements affect the quality of the fruits as previously mentioned by RIVOIRA (1961) and VAGANOV—SOROKINA (1973). Generally, a high value for total soluble solids was observed after 3 days' storage, but this gradually decreased until it showed a minimum value after an 18 day storage period. The trend of the total soluble solids and firmness behaved in a similar manner, showing marked increases early in storage followed by gradual decreases late in the storage period. These results are in agreement with those reported by RADWAN *et al.* (1965) and CHINNASWAMI (1967).

The results also showed that the chelated elements, especially Fe, raised the acidity of the tomato fruits more than the mineral ones. It fluctuated during storage, reaching a maximum after 6 days and a minimum after a 15 day storage period. The trend of the acidity of fruits was similar to that of the total soluble solids. Logically the acids in the tissues of the fruits are one of the major components with respect to total soluble solids, and both of them showed decreases as the storage time increased. Similar results were obtained on tomato fruits by YAMAGUCHI (1960), RADWAN *et al.* (1965), RHOTON (1967) and ALBEGOR—PATSKEVICH (1972).

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WHEAT GROWTH AND CONSTITUENTS AS AFFECTED BY NITROGEN APPLICATION AND SOIL ALKALINITY

Nitrogen is considered to be the most important nutrient in wheat production. The wheat response to nitrogen application has been tackled by several investigators, and a trend of increase in both the straw and grain yield was obtained. However, no response was detected in the case of fertile soils (McNEAL—DAVIS 1954, WOODWARD 1966, DUDAS *et al.* 1968).

Under our local conditions, nitrogen is the most limiting factor in wheat production. According to studies conducted by the Ministry of Agriculture of the A. R. E. (ANONYMOUS 1965, 1966), it was proposed that 71.4 and 95.2 kg/ha be applied in the delta and upper Egypt, respectively. EL-GABALY (1960) suggested that these levels should be decreased in the case of salt-affected soils compared with fertile ones, although nitrogen was found to be the limiting nutrient. He also added that at high pH values, due to high ESP,* the availability of certain plant nutrients may become so low that the plant cannot absorb them at a rate sufficiently rapid to permit satisfactory growth.

The objective of this study is to evaluate the effect of different soil ESP levels on wheat growth and constituents. In addition, it is important to find out the effect of added nitrogen on wheat plants grown in soils of varying degrees of alkalinity.

A well aggregated, alluvial soil sample was brought from a Giza location, and the particle-size distribution and chemical properties of the soil sample were determined, as shown in Table 1.

Four soil samples of different ESP levels were prepared using Na_2CO_3 solution. These levels were 20.34, 24.13, 29.65 and 33.10, where the original soil was of 10.34 ESP only.

Table 1

Particle-size distribution, soil water extract and exchangeable bases of the initial soil

Soil Texture	Coarse sand	Fine sand	Silt	Clay	$CaCO_3$
Sandy loam	1.2%	56.5%	23.5%	19.1%	1.2%

Soluble ions meq/100 g of soil							Exchangeable cations meq/100 g of soil				
CO_4	HCO_4	Cl	SO_4	Ca	Mg	Na	C. E. C.	Ca	Mg	Na	K
—	2.1	1.0	0.2	0.9	0.8	1.8	29.0	19.0	7.0	2.99	1.5

* ESP = Exchangeable Sodium Percentage

$$= \frac{\text{exchangeable sodium quantity}}{\text{exchangeable capacity of soil}} \times 100$$

A vegetative pot experiment (2 kg of soil/pot) was conduced using these five soil samples and five levels of nitrogen as $(NH_4)_2SO_4$ (namely, 0, 35.7, 71.4, 107.1, 142.9 kg Na/ha), making a total of 25 treatments with three replicates. Giza 155 wheat variety was used in this study (15 plants/pot).

Plant samples were taken at two different stages of growth (40 and 60 days after planting). The plant samples were dried, ground and kept for analysis. The total nitrogen, phosphorus, potassium and sodium in the plant material were determined.

The effect of nitrogen and ESP levels on wheat dry matter. The dry matter content of the wheat plants was affected significantly by both the nitrogen addition and the exchangeable sodium levels (ESP) existing in the soils. The highly significant effect of these factors was obtained for both stages of growth.

The results in Table 2 indicate that there is a significant increase in dry matter content as a result of nitrogen application in the 1st and 2nd stages of growth. The N1, N2 and N3 levels of nitrogen caused a significant increase in dry matter content at the 1% level, compared to that of the control. The nitrogen level N4 caused a distinct decrease in dry matter as compared with the N1, N2 and N3 levels and was almost equal to the control (N0). This decrease in dry matter in the case of level N4 could be explained on the basis of varietal response to high doses of nitrogen (KHALIL *et al.* 1971).

The influence of different ESP levels on wheat plant dry matter during the first stage of growth is shown in Table 2. It is noteworthy that increasing the ESP levels up to 29.65 ESP caused a distinct increase in dry matter, although it was not significant, whereas a significant decrease was observed at the 33.10 ESP level. During the second stage of growth (60 days) an increase in the dry matter content was obtained by increasing the soil ESP to 24.13, but

Table 2

The effect of nitrogen application and exchangeable sodium % (ESP) on wheat dry matter in g/pot

A. First stage of growth (40 days after planting)

1. Nitrogen effect on wheat dry matter:

0	35.7 kg	71.4 kg	107.1 kg	142.9 kg nitrogen$_8$ha
(NO)	(N1)	(N2)	(N3)	(N4)
1.265	1.915	1.730	1.810	1.370 g/pot

2. Soil ESP effect on wheat dry matter: (Neglecting the effect of nitrogen addition: i.e. the nitrogen addition effect is averaged for all nitrogen treatments.)

10.34	20.34	24.13	29.65	33.10 ESP
1.620	1.760	1.730	1.635	1.345 g/pot

L. S. D. at 1% level = 0.250 g.

B. Second stage of growth (60 days after planting)

1. Nitrogen effect on wheat dry matter: (Neglecting the ESP effect)

(N0)	(N1)	(N2)	(N3)	(N4)
3.425	4.380	4.395	4.125	3.330 g/pot

2. Soil ESP effect on wheat dra matter: (Neglecting the effect of nitrogen addition)

10.34	20.34	24.13	29.65	33.10 ESP
3.230	3.955	4.985	4.165	3.420 g/pot

L. S. D. at 1% level = 0.790 g

a significant decrease was noticed at the 29.65 and 33.10 ESP levels. These findings agree with the results of MOUSTAFA *et al.* (1966) who reported that wheat growth was markedly decreased by increasing the soil alkalinity.

Although the interaction between ESP and nitrogen levels is insignificant for both stages of growth, the results indicate that wheat response to nitrogen application is always dependent on soil ESP. In other words, the wheat plant responded to nitrogen additon up to the N3 level in the case of soils with ESP levels up to 24.13 whereas higher levels of ESP limited the beneficial effect of nitrogen up to the N2 level.

The effect of nitrogen and ESP levels on wheat mineral constituents

A. Nitrogen. The results in Table 3 indicate that there is an increase in both nitrogen removal* and in the percentage of nitrogen in the plant as a result of the increase in nitrogen application in both stages of growth. This trend was generally observed in the case of soils with ESP levels of up to 24.13. However, the application of higher levels of nitrogen resulted in a decrease in nitrogen removal in the case of soils with 29.65 and 33.10 ESP.

The trend of this increase as well as the decrease in plant nitrogen content as a result of nitrogen application is in accordance with that of the dry matter (Table 2). A similar conclusion was reached by CARTER—SCHOLL (1962).

In spite of the distinct decrease in nitrogen % which occurred at the second stage of growth as compared with the first stage of growth, the total removal at this stage exceeds that of the first stage. This could be mainly attributed to the increase in the plant dry matter content.

B. Phosphorus. The results in Table 3 indicate that the increase in soil ESP levels was accompanied by an increase in plant phosphorus % at both stages of growth. Moreover, the increase in soil alkalinity increased the phosphorus removal during the first stage, which could be attributed to the increase in P% rather than the increase in dry matter. FAWZI—ABED (1975) pointed out that both $CO_3^{=}$ and HCO_3^{-} in irrigation water increased the exchangeable sodium in the soil, and this was accompanied by an increase in the P content of the plants.

The data presented in Table 3 reveal that there was an increase in P% in the plant material as a result of nitrogen application, up to a certain level, but thereafter a decrease in P% occurred. In other words, the application of nitrogen only increased the P% in plants up to the N1 level, after which a gradual decrease occurred.

C. Potassium and Sodium. In the case of soils containing 10.34 ESP, the application of increased amounts of nitrogen were met with an obvious increase in both K% and potassium removal. As the soil ESP increased, this trend could only be observed after the application of low levels of nitrogen (N1 and N2). Soils with higher ESP levels lessened the tendency of nitrogen application to increase K% and K removal. The status of both nitrogen and potassium in the plant was affected in a similar manner by the nitrogen application, where a highly significant correlation existed between removal of N and the K% ($r = 0.884$ and 0.431 in the 1st and 2nd stages of growth respectively).

On the other hand high levels of sodium % were observed as the alkalinity increased. Similar results were obtained by EL-GABALY (1955), MOUSTAFA *et al.* (1966) and EL-KOBBIA *et al.* (1969), where the gain in sodium increased as the soil ESP increased. Both Na% and sodium removal have an opposite trend to potassium, and a negative correlation was obtained between K% and Na% in both stages of growth. However, it is only significant in the case

* Nitrogen removal (mg N/pot) = nitrogen percentage × dry matter/pot.

of the second stage (r = −0.545). These findings are in agreement with the results of FREEMAN (1967) and LARSON—PIERRE (1953).

Generally, it could be stated that all the nitrogen applications produced a tendency to increase in the sodium status, even in soils with a high ESP, whereas both K% and K removal were relatively low. The above-mentioned results indicate that the wheat response to nitrogen application (as dry matter content) depends on the soil ESP level. The increase in ESP lessens the wheat response to nitrogen, whereas an increase in dry matter was obtained by increasing the nitrogen addition in the case of soils having a low ESP. At 29.65 and 33.10 ESP, the increase in dry matter was observed only with the N1 level of nitrogen application. Moreover, the variation of the plant nitrogen removal at the applied doses due to the effect of ESP levels shows a similar trend.

The evaluation of wheat response (using dry matter and constituents as parameters) to nitrogen under different soil ESP levels might be misleading. However, unpublished data (ZANATI *et al.*) reveal that the dry matter content corresponds equally well with the grain crop as affected by different levels of nitrogen and alkalinity, where the efficiency of nitrogen decreases with the increase in soil ESP.

*

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INFLUENCE OF THE DISTANCE OF POLLEN DONOR VARIETIES ON THE FRUIT YIELD OF JONATHAN APPLES

The most important commercial apple varieties grown in Hungary (Jonathan, Starking, Golden Delicious) are totally self-sterile, and since they are mutually cross-fertile, are planted together.

On the farms the ratio of the pollen donor varieties is 1 : 1, 1 : 2 for two, and 1 : 1 : 1 for three varieties. The width of the variety blocks generally ranges from 2 to 6 rows.

In the fruit production in Hungary, the apple is the most important fruit species from the point of view of national economy, and among the apples the winter varieties are of the greatest significance. The most important apple variety in Hungary is Jonathan; this variety gives the bulk of the export. As pollen donors for Jonathan, Golden Delicious and Starking are grown primarily.

The authors' investigations were aimed at clarifying the influence of the distance and arrangement of the pollen donor varieties (Starking and Golden Delicious) on the fruit yield of the apple variety Jonathan.

The investigations were carried out in 1970 and 1971 at Hodász (Szabolcs-Szatmár county). The plantation consists of 15 year old trees grafted to M. 4 root-stocks.

The yield was determined by weighing; the average yield data were obtained from 10 replications per tree.

The effect of the distance of the pollen donor variety Golden Delicious on the yield of Jonathan can be seen in Table 1.

Table 1

Effect of the distance of the pollen donor variety Golden Delicious on the fruit yield of Jonathan (1970—1971, Hodász)

Distance from the pollen variety (m)	Fruit yield (kg/tree)		Fruit below 60 mm (%)	
	1970	1971	1970	1971
8	128*	185	3.0	5.2
16	112	180	2.2	5.1
24	108	142	2.0	4.8
32	93	115	1.0	4.0
40	90	102	0.0	1.5

Root-stock: M. 4
Age of the plantation: 15 years
* Average of 10 trees per treatment

Fruit yield per tree ranged from 128 to 185 kg at a distance of 8 m from the row of the pollen donor Golden Delicious, and from 90 to 102 kg in the case of 40 m. With an increasing distance from the row of the pollen donor a decrease in the fruit yield could be observed.

The influence exercised by the distance of the Starking pollen variety on the fruit yield of Jonathan is shown in Table 2.

Table 2

Effect of the distance of the pollen donor variety Starking on fruit yield in Jonathan (1970—1971, Hodász)

Distance from the pollen variety (m)	Fruit yield (kg/tree)		Fruit below 60 mm (%)	
	1970	1971	1970	1971
7.5	85*	92	2.2	4.5
15.0	70	78	1.5	3.2
22.5	57	70	0.0	1.4
30.0	39	61	0.3	0.0
37.5	34	48	0.8	0.0
45.0	29	37	0.0	0.0

Root-stock: M. 4
Age of the plantation: 15 years
* Average of 10 trees per treatment

Fruit yield per tree at a distance of 7.5 m from the row of the pollen variety was 85—92 kg, while ranging between 29 and 37 kg at a distance of 45 m. Of the pollen donor varieties, Golden Delicious induced a larger amount of fruit than Starking, with the same distance taken into consideration. These observations agree with the data of fruit setting studies. The flowers of the variety Jonathan were made fertile to a lower extent by the Starking pollen than by the pollen of the variety Golden Delicious.

A comparison of the effects of arrangement of the pollen donor varieties Golden Delicious and Starking on the fruit yield of Jonathan is contained in Table 3.

As regards the arrangement of the pollen donor varieties the four possible variations were examined.

Fruit yield per tree is largely determined by the way the pollen donor varieties are arranged. Pollen donor trees placed on all four sides of the Jonathan block ensure the largest amount of fruit in the case of both pollen varieties.

When choosing the pollen donor the following aspects must be taken into account:

— the pollen variety should be intercompatible with the variety to be pollinated;
— their flowering times should coincide, at the time of mass flowering they should blossom together;
— the pollen donor varieties should produce pollen regularly and abundantly every year, and the pollen should be highly active;
— the pollen donor and the variety to be pollinated should start bearing at the same time;
— the pollen variety should have a high production and marketing value;

Table 3

Effects of the arrangement of the pollen donor varieties Golden Delicious and Starking on fruit yield in Jonathan trees spaced at 7.5 × 4.5 m (1970—1971, Hodász)

Pollen donor variety	Arrangement of the pollen variety	Jonathan			
		fruit yield		fruit below 60 mm	
		1970	1971	1970	1971
		(kg/tree)		(%)	
Golden Delicious	On one side of Jonathan	45*	65	2.9	4.5
	On 2 sides of Jonathan	52	76	3.1	4.7
	On 3 sides of Jonathan	61	78	3.8	5.1
	On 4 sides of Jonathan	69	83	4.7	5.4
Starking	On side one of Jonathan	37	49	2.5	3.8
	On 2 sides of Jonathan	39	57	2.5	4.3
	On 3 sides of Jonathan	43	60	2.8	4.5
	On 4 sides of Jonathan	47	64	3.1	4.7

Root-stock: M. 4
Age of the plantation: 15 years
* Average of 10 trees per treatment

— the producer has to determine the number, ratio, distance and arrangement of the pollen donor varieties in such a way as to ensure the highest possible fruit setting and yield.

*

Prepared at the Department of Plant Genetics and Breeding of the University of Horticulture, Budapest, and at the Fruit Growing Department of the Horticultural College, Kecskemét.

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STUDIES ON INTERRELATIONSHIPS BETWEEN SEED YIELD AND ITS COMPONENTS IN SOME EXOTIC STRAINS OF LINSEED (LINUM USITATISSIMUM L.)

Breeding for improvement of seed yield in linseed, an important oil-seed crop in India, has so far been done on a limited scale. Most of the present cultivars are either direct selections from local strains or have been derived by intercrossing them. This has resulted in a reduction of genetic variability in indigenous stock to such an extent that further improvement of the genetic base through the collection and assessment of both indigenous and exotic germ plasm is a prime necessity for crop improvement. To facilitate a proper choice of parents in a breeding programme, it is desirable to examine the nature and magnitude of associations between seed yield and its components. With this objective, twenty eight exotic and two improved Indian varieties of *Linum usitatissimum* L. were studied for interrelationships between seed yield and its contributing factors using correlation and path coefficient analyses. The results of the investigation are reported in this paper.

Twenty eight exotic varieties and two improved Indian varieties, namely, Mukta and NP (RR) 9, were grown in a randomized complete block design with three replications in the rabi season of 1968–69 and 1969–70 at the Indian Agricultural Research Institute Farm, Delhi, with normal doses of fertilizer and irrigation. Each plot consisted of three rows each 3 m in length. The plants were spaced 15 cm apart within the row in both years, while the inter-row distance was 45 cm and 30 cm in the first and second year, respectively. Five plants were selected at random from the middle row to record observations for plant height (cm), number of tillers per plant, days to maturity of bolls from date of sowing, number of bolls per plant, 1000-seed weight (g), number of seeds per five bolls, and seed yield per plant (g). Plot means were used for the analysis of variance and covariance separately for two years. The following form of analysis was employed for the estimation of genotypic variance and covariance.

Source of variation	D. F.	MS	EMS	EMSP
Replications	(r–1)			
Varieties	(v–1)	M1	$\sigma_e^2 + r\sigma_g^2$	$\sigma_e^2 + r\sigma_{g12}^2$
Error	(r–1) (v–1)	M2	σ_e^2	σ_e^2

where σ_g^2 or $\sigma^2 g12 = M1 - M2/r$

$\sigma^2 ph$ or $\sigma^2 ph12 = \sigma^2_g + \sigma^2_e$ or $\sigma^2_{g12} + \sigma^2_e$

σ^2_g = Genotypic variance

σ^2_{g12} = Genotypic covariance between characters 1 and 2

σ^2_{ph} = Phenotypic variance

σ^2_{ph12} = Phenotypic covariance between characters 1 and 2

σ^2_e = Error variance

v = Varieties

r = Replications

Correlation coefficients at phenotypic and genotypic levels between all possible pairs of seven characters were computed according to the following formulae given by AL-JIBOURI *et al.* (1958).

$$\text{Phenotypic correlation coefficient, } r_{ph12} = \frac{COV_{ph12}}{\sqrt{(VAR_{ph1})(VAR_{ph2})}}$$

$$\text{Genotypic correlation coefficient, } r_{g12} = \frac{COV_{g12}}{\sqrt{(VAR_{g1})(VAR_{g2})}}$$

Path coefficient analysis was performed as suggested by DEWEY–LU (1959) at genotypic level using seed yield as effect and six other characters as causes by solving the following simultaneous equations.

$$r_{17} = P_{17} + r_{12}P_{27} + r_{13}P_{37} + r_{14}P_{47} + r_{15}P_{57} + r_{16}P_{67}$$
$$r_{27} = P_{27} + r_{12}P_{17} + r_{23}P_{37} + r_{24}P_{47} + r_{25}P_{57} + r_{26}P_{67}$$
$$r_{37} = P_{37} + r_{13}P_{17} + r_{23}P_{27} + r_{34}P_{47} + r_{35}P_{57} + r_{36}P_{67}$$

$$r_{47} = P_{47} + r_{14}P_{17} + r_{24}P_{27} + r_{34}P_{37} + r_{45}P_{57} + r_{46}P_{67}$$
$$r_{57} = P_{57} + r_{15}P_{17} + r_{25}P_{27} + r_{35}P_{37} + r_{45}P_{47} + r_{56}P_{67}$$
$$r_{67} = P_{67} + r_{16}P_{17} + r_{26}P_{27} + r_{36}P_{37} + r_{46}P_{47} + r_{56}P_{57}$$

The residual effect, which is attributed to unaccountable factors, was obtained from the following equation.

$$\begin{aligned}1 = {} & P^2_{X7} + P^2{}_{17} + P^2_{27} + P^2_{37} + P^2_{47} + P^2_{57} + P^2_{67} + 2P_{17}r_{12}P_{27} + 2P_{17}r_{13}P_{37} + \\ & + 2P_{17}r_{14}P_{47} + 2P_{17}r_{15}P_{57} + 2P_{17}r_{16}P_{67} + 2P_{27}r_{33}P_{37} + 2P_{27}r_{24}P_{47} + \\ & + 2P_{27}r_{25}P_{57} + 2P_{27}r_{26}P_{67} + 2P_{37}r_{34}P_{47} + 2P_{37}r_{35}P_{57} + 2P_{37}r_{36}P_{67} + \\ & + 2P_{47}r_{45}P_{57} + 2P_{47}r_{46}P_{67} + 2P_{57}r_{56}P_{67}\end{aligned}$$

where P = Direct path coefficient; P_{X7} = residual effect. 1 = Plant height; 2 = tiller number, 3 = maturity; 4 = boll number; 5 = 1000-seed weight; 6 = seed number; 7 = seed yield.

Table 1

Analysis of variance for seven quantitative characters in 1968—69 (I) and 1969—70 (II)

Source of variation	d. f.	M. S. S.						
		Plant ht.	Tiller no.	Maturity	Boll no.	*1000-seed wt.	Seed no.	Seed yield
Replications	2	107.91*	21.10	6.91	14022.43	0.28	3.10	192.19*
I								
II		266.11**	7.23**	42.15*	14298.50**	0.37	12.86	15.84**
Varieties								
I	29	666.23**	37.79**	31.28**	8655.48*	9.54**	20.20**	48.70**
II		532.22**	3.58*	21.55*	1814.02	6.42**	38.68**	9.52**
Error								
I	58	30.43	8.72	9.12	4937.60	0.18	9.62	18.81
II		16.10	1.43	13.51	1189.34	0.22	8.56	2.46
Mean								
I		88.7	10.7	174.1	280.5	6.0	42.1	14.9
II		67.1	4.8	152.9	102.7	5.6	40.6	4.0
S. E. ±								
I		3.18	1.70	1.71	40.47	0.24	1.71	2.50
II		2.32	0.69	2.12	19.91	0.85	1.69	0.86
C. V.								
I		16.9	40.1	23.3	27.7	29.9	8.6	35.1
II		20.44	30.3	2.63	36.1	27.0	10.6	52.9

* Significant at 5%, ** Significant at 1%

The results of analysis of variance for all the seven characters together with their means, mean standard errors (S. E.) and phenotypic coefficients of variability (C. V.) are presented in Table 1. The varieties differed significantly from each other with respect to all the characters studied in both years except for boll number in the second year. The means of all the characters in the first year were relatively higher than those in the second year because of the greater inter-row distance in the former year.

Estimates of correlation coefficients between various characters at phenotypic and genotypic levels are shown in Table 2. Only the genotypic correlations are discussed here. The correlations of seed yield with plant height, boll number and 1000-seed weight were strong and consistent in both years. Boll number and 1000-seed weight affected seed yield positively, and plant height negatively. Among the yield components, the negative correlation of 1000 seed weight with plant height and tiller number were found to be high and consistent for both years. In general, all these correlation estimates were in agreement with those reported by SAXENA—ASTHANA (1962), PATHAK—BAJPAI (1964), BADWAL *et al.* (1970) and VIJAYKUMAR—VASUDEVANRAO (1974). An exception was noted in the case of the correlation between seed yield and tiller number. In the present study, this was negative, whereas a positive correlation between these characters was reported by the above workers.

It is well known that a complex character like seed yield is influenced directly and indirectly by its components. Simple correlation analysis does not reveal the indirect associations among these characters. The path coefficient analysis helps in estimating the direct and indirect effects on seed yield, and was carried out with this in view. In general, the magnitudes of path coefficients in the first year were relatively higher than those in the second year (Table 3). The direct effects of plant height, boll number and 1000-seed weight corresponded in sign and magnitude with their correlations with seed yield in the first year. However, the dire ct effects of tiller number, maturity and seed number were positive in contrast to their negative correlations with seed yield. The positive and direct effect of tiller number changed into negative correlation through the negative indirect effect of the 1000-seed weight. Similarly, the positive and direct effect of maturity was counteracted by negative indirect effects, particularly those of boll number, plant height and 1000-seed weight, with the result that the correlation between seed yield and maturity was negative. The combined negative indirect effect of plant height, maturity and 1000-seed weight counterbalanced the strong positive direct effect of seed number, resulting in weak correlation. In the second year, the direct effect of only boll number and 1000-seed weight were worth noting; the rest of the characters either showed no direct effects or had weak direct effects and their strong correlations with seed yield were due to the indirect effects of other characters. However, in the case of boll number, its strong correlation with seed yield was not entirely due to its direct effect, but was the result of the interaction of direct and indirect effects through the 1000-seed weight.

Thus, it is apparent from the results that two traits, viz. boll number and 1000-seed weight, exerted a profound influence on the seed yield. BADWAL *et al.* (1970), ABRESCHTSEN—DYBING (1973), and VIJAYKUMAR—VASUDEVANRAO (1974) reached the same conclusion in their path coefficient studies in linseed and flax. The negative association of seed number with 1000-seed weight was significant in one year but not so in the following year, i.e. the relationship was not consistent, thereby indicating that the fertility did not greatly affect the seed size in the present population. This is a favourable situation for the improvement of seed size, which has usually been reported as negatively correlated with seed number in previous papers on linseed and on several other crops as well.

The enlarged genetic variability due to diverse sources of germ plasm and favourable associations between seed yield components in the present study offers a considerable scope for the further improvement of the population. The productivity potential of the crop can be increased significantly through selection for a higher number of bolls and higher seed weight.

Table 2

Estimates of phenotypic and genotypic correlation coefficients among seed yield and its components in 1968—69 (I) and 1969—70 (II)

Character		Tiller no		Maturity		Boll no.	
		I	II	I	II	I	II
Plant ht.	P	.50**	.21	.49**	.05	.04	—.07
	G	.57	.27	.57	.27	—.46	—.64
Tiller no.	P			.02	—.19	.30	.46**
	G			—.01	.33	.30	.34
Maturity	P					—.22	—.35
	G					—.64	—.09
Boll no.	P						
	G						
1000-seed wt.	P						
	G						
Seed no.	P						
	G						

Character		1000-seed wt.		Seed no.		Seed yield	
		I	II	I	II	I	II
Plant ht.	P	—.67**	—.70**	—.29	—.26	—.73**	—.47**
	G	—.70	—.76	—.32	—.41	—.65	—.77
Tiller no.	P	—.73**	—.33	.28	.03	—.27	.17
	G	—.81	—.42	.37	.02	—.52	—.38
Maturity	P	—.33	—.03	—.04	—.06	—.35	—.29
	G	—.39	—.32	—.14	—.44	—.61	—.28
Boll no.	P	—.16	.04	.06	.38	.51**	.79**
	G	—.07	.45	—.05	.97	.58	.83
1000-seed wt.	P			—.53**	.12	.41	.54**
	G			—.41	.18	.57	.86
Seed no.	P					—.10	.41*
	G					—.29	.62

* Significant at 5%; ** Significant at 1%
P Phenotypic; G Genotypic

Table 3

Break up of genotypic correlations between seed yield and its components into direct and indirect path coefficients in 1968—69 (I) and 1969—70 (II)

Characters		Effect via						
		Plant ht.	Tiller no.	Maturity	Boll no.	1000-seed wt.	Seed no	Correlation with seed yield
Plant ht.	I	−5.27	2.21	4.87	0.01	−3.61	1.15	−.65
	II	−0.08	−0.01	0.02	−0.14	−0.48	−0.08	−.77
Tiller no.	I	−3.03	3.84	−0.12	1.64	−4.18	1.32	−.52
	II	−0.02	−0.02	0.02	−0.02	−0.36	0.02	−.38
Maturity	I	−3.02	−0.05	8.49	−3.50	−2.01	−0.51	−.61
	II	−0.02	−.001	0.06	−0.03	−0.20	−0.09	−.28
Boll no.	I	−0.01	1.16	−5.48	5.43	−0.35	−0.18	.58
	II	0.04	0.01	−0.01	0.31	0.28	0.19	.83
1000-seed wt.	I	3.68	−3.11	−3.30	−0.37	5.17	−1.49	.57
	II	0.06	0.01	−0.02	0.14	0.63	0.04	.86
Seed no.	I	−1.69	1.41	−1.21	−0.27	−2.14	3.61	−.29
	II	0.03	−.001	−0.02	0.30	0.11	0.20	.62

Underlined figures are direct effects
Residual effect I = 0.57; II = 0.43

Furthermore, a hybridization programme involving the use of diverse parents with desirable characteristics, particularly boll number and seed weight, might be expected to result in the increase of seed yield.

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AN EARLY MEXICAN WHEAT CULTIVAR FOR EGYPT

With few exceptions crop production in the countries of the near east is dominated by cereals, which occupy about 70% of the total harvested area. Over the past 15 years or so the cereal production in the region has risen by only about 2% on average, though there are wide annual fluctuations. The overall increase has been insufficient to meet the rapidly growing demand. The aridity of the region limits the expansion of the cereal acreage and therefore the key to increased cereal production in the near east lies in raising the yields. This need has been recognised for some time and has led to the initiation of coordinated yield trials. These trials have resulted in the identification of a number of high yielding Mexican wheat varieties which are well adapted to the environmental conditions of the region (ANONYMOUS 1969).

The introduction of these high yielding Mexican cultivars is only just getting underway, and in some countries, e.g. Lebanon and Syria, it is only at the experimental stage. In Egypt significant beginnings in the use of high yielding wheat varieties have been made despite the shortage of fertilizers and extention personnel. Economic incentives have been provided to farmers to raise productivity.

In spite of exceptionally unfavourable weather and a serious attack of rusts in 1969, the yields of Mexican varieties are still expected to be higher than those of local varieties (ANONYMOUS 1969).

In the USSR, Mexican cultivars were introduced by several workers to improve Russian cultivars and to introduce valuable genes into commercial varieties. ORLYUKA—SOBKO (1974) successfully induced highly productive ears and increased the percentage of protein and gluten in Russian cultivars by crossing with Sonora 64. PRILYUK (1974) succeeded in obtaining short-stemmed cultivars in cross combinations with Sonora 64. HANNA (1973) indicated that crosses between Mexican varieties and Sonora 64 were promising as regards increasing the yield. REHAB *et al.* (1975) indicated the need to introduce a short season wheat cultivar in Egypt. The present investigation is an attempt to produce such a cultivar.

Ten cultivars were grown each in four small plots of 19.7 m^2 for five years starting in 1970. The cultivars were given the agronomic treatment usual for wheat cultivation in Egypt. A complete randomized block design was used to compare the cultivars with regard to yield, earliness and percentage protein. The yield was measured in kilograms and earliness in days from the date of planting to the date of harvest, while the percentage protein was based on random samples of the grains. The average of five years was used in the statistical analysis and LSD was used to compare the means.

Table 1 gives the mean per plot over five years for the different varieties used with regard to grain yield, earliness and percentage protein. The analysis of variance for these traits are given in Table 2.

Table 1

The average per plot for grain yield, earliness and percentage protein

Cultivar	Average yield per plot (kg)	Earliness (days)	Percentage protein
Sonora 64	1.574	150.5	9.825
Pitic 62	1.515	183.0	8.075
Siete Cerros	1.018	176.3	8.775
Lerma Rojo	1.093	160.0	8.075
Mexipak	1.019	171.5	8.550
Bajio 67	0.902	158.2	8.825
Tobari 66	0.864	157.6	8.725
Nainari 60	0.845	177.0	8.675
Inia 66	0.788	169.3	10.000
Giza 155	0.731	176.3	7.700
LSD	0.158	10.3	1. 91

Table 2

Analysis of variance for the three traits

Source	d. f.	Yield		Earliness		Protein	
		M. S.	F.	M. S.	F.	M. S.	F.
Varieties	9	0.239	3.36**	465.5	18.39**	2.122	2.395*
Blocks	3	0.134	1.74	7.3	0.289	0.163	0.018
Error	27	0.077		25.3		0.886	

* Significant at 5%
** Significant at 1%

The various varieties showed highly significant differences in grain yield per plot. The cultivar Sonora 64 was the highest yielder in comparison with others under the same environmental conditions, while the Egyptian cultivar Giza 155 was the poorest in this respect.

Apart from slight variations the results were consistent during the whole period of the experiment.

The earliest variety was Sonora which required on average 150.5 days from the date of planting to the date of harvest, while Pitic 62 was the latest variety, requiring 183 days. Highly significant differences were found between the varieties in this trait.

The varieties showed significant differences in the percentage protein. It is apparent from Table 1 that the varieties Inia 66 and Sonora 64 were the highest in protein content and the difference between them was significant.

From the results obtained in this paper, the cultivar Sonora 64 appears to be a good prospective variety for Egypt. Sonora 64 was the highest in yield and was the earliest during the whole period of the experiment. The results were consistent during the period from 1970 to 1974. The cultivar Inia 66 exceeded the variety Sonora 64 with regard to percentage protein but the difference was not significant. The authors recommend the cultivar Sonora 64 to be grown on a large scale in Egypt to increase wheat productivity and to obtain the maximum yield in a relatively short period. The cultivar Sonora 64 has reddish coloured grains, but this deficiency is a minor one compared to its useful traits. Moreover, the colour of the grains could be improved by a carefully designed backcross programme with Giza 155 as a donor for the grain colour trait.

In fact, more comprehensive genetic studies of the traits carried by Sonora 64 are needed in order to get a good substitute for Giza 155. The information obtained in this experiment seems to indicate that Sonora 64 has a valuable germplasm which should be better exploited.

The authors are currently carrying out a genetic investigation of the economic traits in Mexican cultivars in line with these evaluation studies, similar to the work of IBRAHIM—ABUL-NAAS (1974).

Monosomic analysis for these traits is also needed to help in establishing investigations on gene and chromosome transfer and in achieving a permanent wheat cultivar.

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CHANGES IN ASCORBIC ACID DURING IN VITRO POLLEN TUBE DEVELOPMENT IN PINUS ROXBURGHII SARG.

The chemistry of pollen grains has been relatively well studied (STANLEY 1973). The mineral contents, carbohydrates, organic acids, amino acids, proteins, nucleic acids, pigments, vitamins and steroids have been analysed (STANLEY—LINSKENS 1974). In some plants, e.g. *Pinus montana*, *Almus miona* and *Zea mays*, etc., pollen vitamin contents have also been analysed. In general, *Pinus* pollen contained a high amount of ascorbic acid in μg/g dry weight. Several functions have been assigned to ascorbic acid (CHINOY 1969, LALORAYA *et al.* 1972) but their specific role in pollen tube metabolism is not clear. In fact no work is available on the changes in ascorbic acid during pollen germination except a histochemical study by

Mehan—Malik (1976). The pollen tube formation is a morphogenetic process, comparable to the cellular differentiation (Malik 1974) and is accompanied by profound changes in the cellular metabolism. Presumably qualitative and quantitative changes in the cellular constituents occurred during pollen tube elongation.

This communication describes the changes in the level of ascorbic acid (ASA) during the germination of pollen in *Pinus roxburghii* and attempts to examine its role in pollen tube development.

Pollen grains of *Pinus roxburghii* were incubated in a liquid culture medium, comprising 10% sucrose at 28 ± 2°C in sterilized cavity dishes, and were allowed to germinate for 70 hr. Cultures were grown in either complete darkness or in the daylight available from fluorescent tubes giving an intensity of about 1200 lux at the level of the cultures. The ascorbic acid content was estimated after 0, 20, 40 and 60 hr of incubation. For the estimation of ASA, 50 mg of pollen was used and it was homogenized in 2 ml of 0.5% oxalic acid solution using a chilled pestle and mortar. The homogenate was filtered in a test tube and allowed to stand for 30 min. To this, 5 ml of amyl-alcohol was added and this was followed by the addition of 3.2 ml of 5 mg% of dichlorophenolindophenol prepared in water to the lower layer. The test tube was shaken for 5 min and allowed to stand. The upper layer was centrifuged and OD was measured at 546 nm with the help of spectronic-20 (Bausch and Lomb). For the controls, the same procedure was adopted except that the addition of pollen grain extract was omitted. The histochemical localization of ASA was made following the fixation of dormant and germinating pollen in an acidic-alcoholic solution of $AgNO_3$ in the cold. The reduction of $AgNO_3$ resulted on the formation of brown or black granules. The occurrence of granules indicated the presence df ASA. Phenols and peroxidase levels were also studied colorimetrically by the procedures described by Laloraya *et al.* (1972).

Pollen grains were characterized by the presence of high ASA activity. Some of the pollen lacked ASA and failed to germinate even after 60 hr of incubation. The pollen was treated with $CuSO_4$ and there was a reduction in the ASA activity. This suggested the presence of flavonoids as well. Pollen grains which were stored under ordinary room conditions had an extremely low activity when tested for ASA.

Histochemical localization also revealed the presence of ASA in the pollen cytoplasm and pollen tubes. The intensity of ASA was especially strong in the tip of the pollen tubes.

There were marked differences in the percentage of germinating pollen when incubated in the dark or in light conditions. The percentage of germination was comparatively high when the pollen was incubated in the dark. Although the overall pattern of utility and biosynthesis was comparable under the two conditions of incubation, some differences were nevertheless observed. For instance, in the first 40 hr of germination, the amount of ASA continuously decreased and thereafter it continued to increase. It can be observed from Fig 1. that the decrease was more pronounced when incubation was carried out in the light while in the dark the depletion of ASA was comparatively less.

The vitamin contents of *Pinus montana*, *Almus miona* and *Zea mays* pollen have been analysed (Stanley 1973). In general *Pinus* pollen contains a high amount of ASA in μg/g dry weight of pollen. Several roles have been proposed for the ASA (Mapson 1958, Chinoy *et al.* 1973) but its specific role in pollen metabolism is not clear.

In the present studies the amount of ASA in pollen, grown in the dark decreased less rapidly compared to that of pollen grown in the light. The decrease in the amount of ASA stimulated tube emergence and its early growth. However, it is not possible to estimate the amount of ASA present in the pollen and the pollen tubes separately. It is of considerable interest that Mehan—Malik (1977), using histochemical methods, demonstrated the presence of ASA in the pollen and also in the pollen tubes. Furthermore, the reaction of ASA persisted in the pollen during different phases of germination though its intensity decreased. With the increased period of germination ASA increased in the tube tip. Our studies support the observations of MEHAN—MALIK (1977). It is generally known that compared with the dried seeds, there is an increased biosynthesis of ASA after soaking and during germination (ISHERWOOD—MAPSON 1962, TEWARI—RATHORE 1973). However, in the pollen a reverse situation is encountered. For instance, the dried seeds lacked ASA while ripe, whereas ungerminating pollen contained an abundant ASA content. It is difficult to think of the reason for such a decrease in the initial stages of pollen germination except that it indicates the continuous utilization of the ASA reserves. The biosynthesis of ASA begins only after 40 hr of incubation, when the sucrose from the basic medium is available.

Since it was first isolated, the biosynthesis and distribution of ASA has been worked out in several plant species (ISHERWOOD *et al.* 1954, ISHERWOOD—MAPSON 1962, MAPSON 1958). CHINOY *et al.* (1973), LALORAYA *et al.* (1972), TEWARI—RATHORE (1973) and WAHAL *et al.* (1973) studied the quantitative distribution of ascorbic acid in the tissues of different systems. MOHAN—KHANNA (1974) studied the ascorbic acid metabolic and growth in a *Datura* tissue culture.

The occurrence of ASA and DHA (dehydroxyascorbic acid) has been described in different organisms; the former occurs in relatively high concentrations in plant and animal tissues. DAVE *et al.* (1969) described a cytochemical method for the localization of ascorbic acid. LALORAYA *et al.* (1972), SETHI—MALIK (1974) and MALIK—VERMANI (1975), using histochemical procedures, localized ASA in different tissues. It is generally suggested that ASA plays a significant role in the differentiation of different tissues in higher plants. Pollen grains, when incubated in the growth medium, put forth pollen tubes. The formation of pollen tubes is comparable to cellular differentiation and is a morphogenetic phenomenon (MALIK 1974). Recent studies from this laboratory indicate profound changes during the cellular metabolism and, presumably, qualitative and quantitative changes in the cellular constituents occur during pollen tube growth. In the light of these inferences it may perhaps be assumed that ASA is concerned with the processes controlling the growth and elongation of pollen tubes. The elongation of pollen tubes is a process of cell enlargement and there is no nuclear division. EDGAR (1970) observed that an increase in DHA inhibited cell division but promoted cell enlargement. It seems to us that an ASA-DHA system may be a possible mechanism contributing towards pollen tube elongation. It is worth mentioning that our cytochemical tests supported the earlier observations of MEHAN—MALIK (1977) regarding high activity in the pollen tube tip. It is worthwhile mentioning that the active growth of the tube is restricted to the tip region (ROSEN 1973). Seemingly ASA is oxidized to DHA by some mechanism during the initial 40 hr of incubation. In *Pinus roxburghii*, after up to 40 hr of incubation in sucrose the starch synthesis was observed to be maximum (SINGH *et al.* 1976), ind·cating the possibility of mobilization and the direct conversion of sugars into starch. This is a period when ASA also decreased. After 40 hr the amount of starch synthesis decreased but the level of ASA increased. Probably the external sucrose was converted into ASA rather than into starch. The biosynthesis of ASA increased with additional tube elongation. The quantitative estimation of phenols and peroxidase also exhibited an increase with germination and early tube elongation. This increase continued during the first 40 hr of incubation. Evidently some relationship between peroxidase, phenols and ASA could be visualized. It is known that, by acting on phenols, peroxidase produces quinones through an intermediate semiquinone (LALORAYA *et al.* 1972) and the latter triggers the oxidation of ASA to DHA. Peroxidase is also known to act on ASA and produce DHA (CHINOY 1969). It seems to us that peroxidase, phenols and ASA play an important role in the development and differentiation of the tubes. Furthermore, we may add that peroxidase acted on phenols and indirectly regulated the level of ASA. There is an exponential growth of pollen tubes after 20 hr and possibly peroxidase acted on the phenols and acted as the terminal oxidase in pollen tube formation, while, coupled to the oxidation of ASA, it serves as a source of energy for the prevalent metabolic activities. It may be suggested that with the action of ASA-reductase activity a considerable amount of electron flow would be maintained without any involvement of O_2 in such a system. In the absence of aerobic respiration during early pollen tube growth, the availability of energy through ASA seems interesting (SINGH *et al.* 1976).

The ascorbate content of pollen tubes decreased during the initial stages of tube formation, which indicated its utility in the actively growing and metabolizing state. It is quite evident that ASA is synthesized from the exogenous sugars of the medium after 40 hr of incubation. The precise role of phenols in exerting a control on the energy reactions is being examined.

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EFFECT OF THE FUNGICIDE "ORTHOCIDE" ON THE DECOMPOSITION OF HUMIC ACIDS

The decomposition of humic acids is brought about by the activities of large numbers of soil microorganisms. Many workers (KUDRINA 1951, ALEKSANDROVA 1953, SCHONWALDER 1958, NIKITIN 1961, MRYSHA 1967, 1969 and ZOHDY 1971) have found that the true humic acid decomposers are *Pseudomonas*, *Corynebacterium*, *Bacillus* and short rods g-bacteria which decompose the complex structure of humic acids to simpler forms. These by-products are utilized by other heterotrophic microorganisms. Therefore, any organic materials passing to the soil could easily be attacked by these microflora.

In agricultural practice, nowadays, fungicides are used extensively. The fungicides applied as seed dressing are of special interest to microbiologists since their concentrations in the seed bed are considerably high. These organic materials, which are toxic to fungus (GORDEN—YOUNG 1960, HAMED 1968 and MAHMOUD *et al.* 1973b), may also have a toxic or stimulating effect on organisms decomposing humic acids. Any agent which affects this group may also impair soil fertility. Therefore, the objective of this investigation is to study the effect of the fungicide "Orthocide", which is used in large amounts on Egyptian soils, on the decomposition of humic acids.

The effect of orthocide on the humic acid decomposition process was investigated by adding pasteurized humic acids, extracted from bodreit (KONONOVA—BELCHIKOVA 1961), at a rate of 0.1%, to a modified Ladd liquid medium in 250 ml conical flasks. These were inoculated with 1 ml of fertile soil suspensions as a source of humic acid decomposers. The orthocide (N-(trichloromethylthio)-4-cyclohexane, 1-2-dicarboximide), was applied at a rate of 0, 1, 10 and 20 ppm. Three replicates were used for each treatment and the flasks were incubated at 30°C. Then samples were taken after 3, 7, 14, 21, 28 and 35 days from all treatments for the following determinations:

1. Total organisms decomposing humic acids, using the Ladd agar medium (LADD 1964) modified by ZOHDY (1971).
2. Total carbon, using Tsyplenkov's method (TSYPLENKOV 1963). The amounts of carbon were calculated from 4 standard curves using the same concentrations of applied orthocide to avoid the amount of carbon in the fungicide.
3. Total volatile acids.
4. Total nitrogen, using the semi-micro-kjeldahl method.
5. Extraction and determination of total soluble nitrogen, using Gallaway's method (GALLAWAY 1958).
6. Extraction and determination of total amino acids, using Rosen's method (ROSEN 1957).
7. pH values, using the Beckman apparatus.

All these determinations comprise the different steps of humus decomposition and any changes in their amounts denote the effect of the fungicide on these important processes.

1. Effect of orthocide on total organisms decomposing humic acids. The data in Table 1 show that, when the orthocide was applied, it stimulated the growth of humic acid decomposers, especially the 1 ppm orthocide treatment. A negative correlation seems to exist between the counts of humic acid decomposers and orthocide concentrations. After 21 days, the counts of this group at 1 ppm orthocide treatment decreased as compared to the control figures. At the 10 and 20 ppm orthocide treatments, the reduction in counts was observed after 28 days. Moreover, the reduction in the count was proportional to the orthocide concentration. This inhibitory effect of the orthocide on humic acid decomposers could be attiibuted to the release of the chlorine of the orthocide as nascent Cl^-, which is toxic to microorganisms. It may also be due to the reaction of the captan group, the "active part of orthocide", with SH groups released during the degradation of humic acids, giving rise to thiophosgene which is very toxic to microflora (INKENS *et al.* 1959, INKENS 1963, MONTIE—HUGH 1962 and HAMED 1968).

2. Effect of orthocide on total carbon content in humic acid decomposing cultures. In Table 2 it can be seen that there is a gradual increase in the concentration of total carbon in the control and orthocide treated cultures, reaching different peaks at different times depending on the orthocide concentration. There alson seems to be a positive relation between the rates of orthocide addition and the amounts of total carbon in the cultures. At the end of the experiment there is a negative correlation between the total carbon and the counts of humic acid decom-

Table 1

Humic acid decomposer counts in humic acid cultures treated with orthocide No. in millions/1 ml culture

Time of sampling in days	Orthocide in ppm			
	Control	1	10	20
2	3,800	8,600	10,700	5,100
7	4,800	15,300	18,600	8,200
14	4,100	57,900	17,500	13,200
21	88,000	48,300	82,200	90,000
28	180,000	160,000	144,000	100,400

Table 2

Total carbon content in humic acid decomposer cultures treated with orthocide mg carbon/100 ml culture

Time of sampling in days	Orthocide in ppm			
	Control	1	10	20
2	36	35	42	57
7	44	39	43	67
14	54	40	48	61
21	35	45	40	57
28	37	41	43	50
35	38	32	36	54

posers. The counts of the humic acid decomposers after 28 days were 180, 160, 144 and 100 million/1 ml culture while the amounts of total carbon were 37, 41, 43 and 50 mg 0/100 ml for 0, 1, 10 and 20 ppm orthocide respectively. This negative correlation may be due to the inhibitory effect of orthocide on the decarboxylation of the oxidizable organic materials by microorganisms causing the accumulation of these materials in the culture. These results are confirmed by the findings of HOCHSTEIN *et al.* (1954) and HOCHSTEIN—COX (1956). OWENS—NOVOTNY (1959) stated that captan affects the cellular metabolism by blocking a key decarboxylation reaction in which thiamine pyrophosphate functions as a co-enzyme. When the counts of humic acid decomposers increased the amount of carbon decreased at the end of the experiment. This may also be due to the adaptation of the organisms to the toxic substances or to the disappearance of thiophosgene or captan from the culture, permitting the organism to oxidize the organic materials to CO_2, which is liberated from the culture. This data corresponds to that of RADWAN (1965) and HAMED (1968) who found that TMTD and orthocide decreased soil respiration and depression in CO_2 production; the subsequent stimulation of respiration was probably due to the utilization of decomposition was probably due to the utilization of decomposition products by microorganisms.

3. *Effect of orthocide on the amounts of total volatile acids in humic acid decomposing cultures.* In Table 3 a gradual increase in the amount of volatile acids in the control and orthocide treatments may be observed. Such increases differed according to the orthocide concentrations and decreased thereafter. Moreover there is a negative correlation between the amounts of these acids and orthocide. In general, there is a positive correlation between the total carbon and the volatile acids. This may be due to the inhibition effect of captan on the decarboxylation of keto acids by microorganisms, thereby inhibiting or altering the further utilization of these acids to terminal respiration of CO_2 and shifting the metabolism of the keto acids to form these simple acids. These results are in agreement with those of MAHMOUD *et al.* (1973a) who found that pyruvic and α-keto glutaric acids were accumulated in the culture treated with orthocide. After a period depending on the orthocide level, the total amount of volatile acids decreased. It may be supposed that the organisms begin to utilize these acids as a source of energy.

4. *Effect of orthocide on the pH values of humic acid decomposing cultures.* The data in Table 4 indicate that the pH values of the treated cultures are lower than those of the control treatment during the experiment, and that the pH values decreased gradually with time. In general, there is a negative correlation between the pH and the amounts of volatile acids and total carbon. The relative decrease in the pH after 21 days in 1 ppm orthocide treatment is due to the high accumulation of both volatile acids and total carbon.

5. *Effect of orthocide on the total nitrogen content of humic acid decomposing cultures.* Table 5 shows that the lower concentration of orthocide inhibited the fixation of nitrogen and gave lower amounts than the control, while 20 ppm orthocide treatment gave higher nitrogen amounts from the first sample denoting that this level of orthocide may have a stimulatory effect on nitrogen fixation besides the amounts of nitrogen initially found in the orthocide added. It is also observed that therc is a gradual increase in nitrogen content in the orthocide treated cultures. This increase is more obvious in the 1 ppm treatment than in the other treatments. It is worth mentioning that the same high peaks of both total nitrogen and total carbon for the different treatments are related. HOCHSTEIN—COX (1956) and MAHMOUD *et al.* (1973a) found that captan inhibited pyruvate breakdown and caused the accumulation of pyruvic and α-keto glutaric acids in the culture. This could explain how the nitrogen fixers in the soil inoculum are able to survive the toxicity of captan by utilizing these keto acids for the fixation of atmospheric nitrogen.

6. *Effect of orthocide on the total soluble nitrogen in humic acid decomposing cultures.* The data in Table 6 show that all the orthocide figures are higher than the control throughout

Table 3

Total volatile acids in the humid acid decomposing cultures treated with orthocide

Time of sampling in days	Orthocide in ppm			
	Control	1	10	20
2	0.3355	0.6379	0.8101	0.1022
7	0.3758	1.3824	0.9201	0.1915
14	1.8245	1.4094	1.2917	0.4550
21	0.4104	3.5352	1.0080	1.0830
28	0.3312	1.0843	0.9538	0.7704
35	0.9432	0.9288	0.8784	0.6667

Table 4

pH values of humic acids decomposing cultures treated with orthocide

Time of sampling in days	Orthocide in ppm			
	Control	1	10	20
2	6.55	6.45	6.45	6.47
7	6.55	6.45	6.47	6.40
14	6.45	6.42	6.35	6.32
21	6.40	6.35	6.32	6.30
28	6.42	6.27	6.22	6.20
35	6.35	6.30	6.17	6.15

Table 5

Total nitrogen content of acid decomposing cultures treated with orthocide mg N/100 ml culture

Time of sampling in days	Orthocide in ppm			
	Control	1	10	20
2	96.28	71.92	73.52	113.92
7	93.12	73.10	94.64	114.00
14	75.60	74.80	139.20	84.40
21	74.40	85.20	68.80	74.16
28	74.80	65.92	68.56	74.28
35	75.50	68.16	68.00	71.48

Table 6

Total soluble nitrogen in humic acid decomposition cultures treated with orthocide mg N/100 ml culture

Time of sampling in days	Orthocide on ppm			
	Control	1	10	20
2	26.60	26.73	33.22	33.01
7	28.41	27.93	33.52	39.26
14	29.02	29.74	33.23	35.64
21	28.01	32.98	34.98	34.71
28	26.17	30.22	36.18	37.64
35	28.44	27.80	37.75	36.52

Table 7

Total amino acids in humic acid decomposing cultures treated with orthocide μg N/1 ml culture

Time of sampling in days	Orthocide in ppm			
	Control	1	10	20
2	100	95	95	90.0
7	115	100	135	112.5
14	120	105	160	112.5
21	105	180	105	130.0
28	115	120	130	170.0
35	95	95	115	125.0

the experiment denoting that the orthocide application slightly stimulated the formation of soluble nitrogen. Moreover, the higher the concentration of applied orthocide the higher the amount of total soluble nitrogen produced. This increase may be due to the mineralization of the nitrogen molecule in the orthocide structure by heterotrophic microorganisms, in addition to the mineralization of organic nitrogen in the humic acid molecule.

7. *Effect of orthocide on the amounts of total amino acids in humic acid decomposing cultures.* The data in Table 7 show that at the beginning of the experiment the total amino acids detected were lower in all orthocide treatments than in the control. After a period depending on the orthocide concentration, the amount of total amino acids increased more than the control. This increase appeared at the same time as the increase in total carbon, total volatile acids and total nitrogen, except in the 20 ppm treatment, which gave the highest figure after 28 days. Further, the total amino acids in the 1 and 20 ppm orthocide treatments were lower than the control during the first 14 days followed by relatively marked increases. These concentrations may cause a partial inhibition of the microorganisms dealing with these materials.

All the orthocide treatments stimulated the production of amino acids and the greater the amount of orthocide applied the higher was the amount of total amino acids obtained.

This may be due to the formation of these amino acids from the simple organic acids formed, especially α-keto acids (MAHMOUD *et al.* 1973a) and this could be attributed either to the adaptation of the organisms to the toxic substances or to the disappearance of these toxicants from the culture.

*

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STUDIES ON METHODS FOR TESTING THE SPECIFIC REPLANT DISEASE IN ORCHARDS

When a species of fruit crop is planted on a given area where the same or a closely related species has been grown before, it often happens that the new trees grow very poorly. This is called "specific replant disease" or specific "soil sickness" (Bodenmüdigkeit, fatigue du sol), if neither many nematodes nor pathogens are living in the rhizosphere causing defects in the growth (Bunt—Mulder 1973, Gilles 1973, Hein 1972, Hoestra 1968, Otto 1973, Savory 1966).

Many experiments have shown that soil disinfection with different anti-microbe chemicals or physical media gives very good results.

It seems that at present the only way to demonstrate the soil sickness is to use the so-called pot bio assay test, comparing growth in different or differently disinfected soils.

Two variants of this method were used in our experiments. 3—5 cm high seedlings were planted in pots as test-plants. The two types of biotest are as follows:

I. Soil samples taken from old orchards were treated with sterilizing chemicals in the autumn. In spring the corresponding seedlings, each 3—5 cm in height, were planted into pots or small containers, e.g. peach seedlings into peach-soil.

II. Soil samples taken from two different orchards were mixed in different proportions. Into one portion of this mixture seedlings of the type grown in one orchard were planted and into the other seedlings of the type grown in the other orchard.

Although there are other aberrances in the stunted seedlings, e.g. the decay of thin roots, the height of the seedlings after two months gave a good indication of the state of health. The number of repetitions was 10 or 20.

The results are summarized in the following tables and figures.

Fig. 1. The effect of soil sterilizing chemicals. Apple seedlings. From left to right: treated with dazomet, untreated, treated with formaldehyde

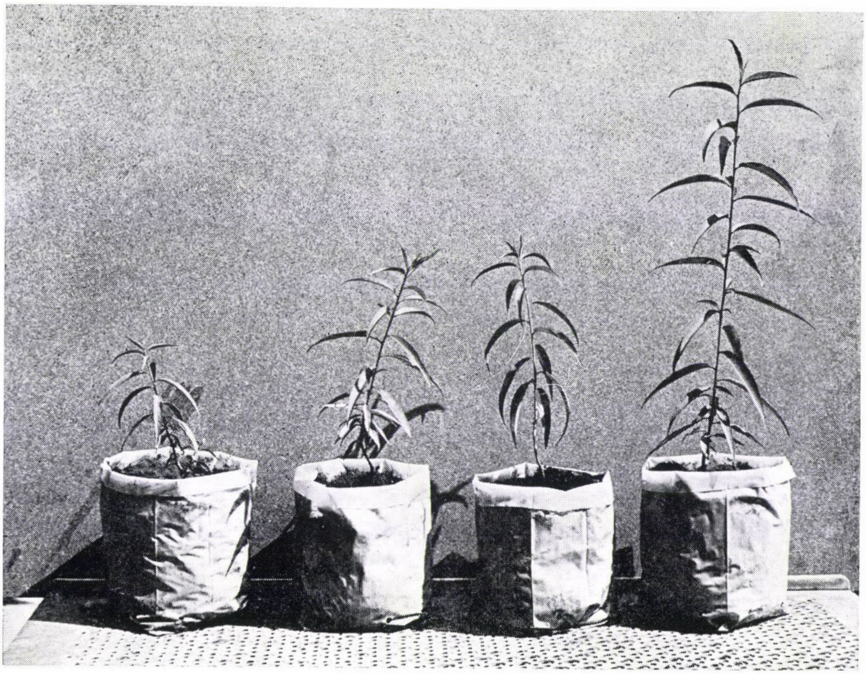

Fig. 2. The effect of soil mixing. Peach seedlings. From left to right: 100% peach soil, 66% peach soil, 33% peach soil, 0% peach soil (= 100% apple soil)

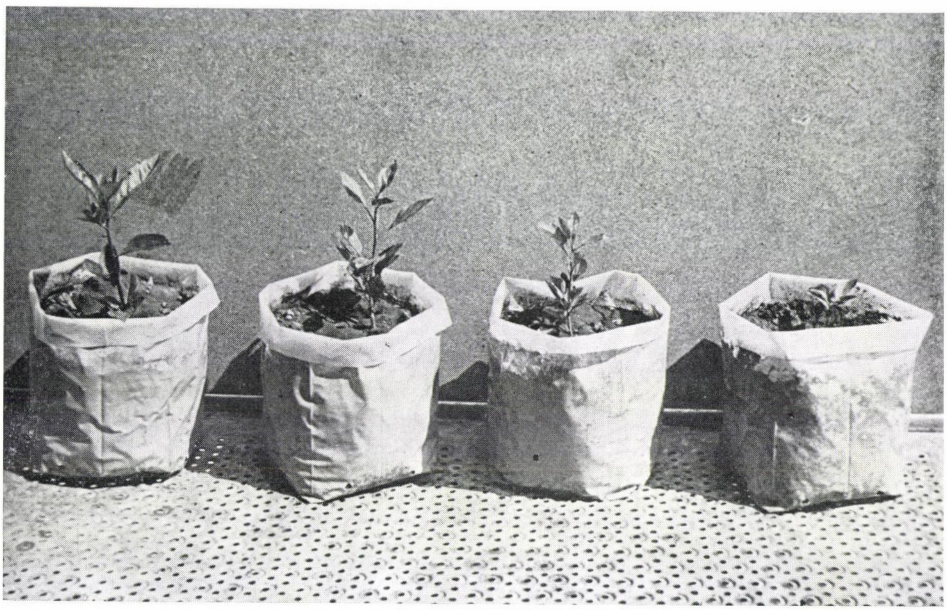

Fig. 3. The effect of soil mixing. Apple seedlings. From left to right: 100% peach soil, 66% peach soil, 33% peach soil, 0% peach soil (= 100% apple soil)

Fig. 4. The effect of soil mixing. Apricot seedlings. From left to right: apricot soil, apple soil

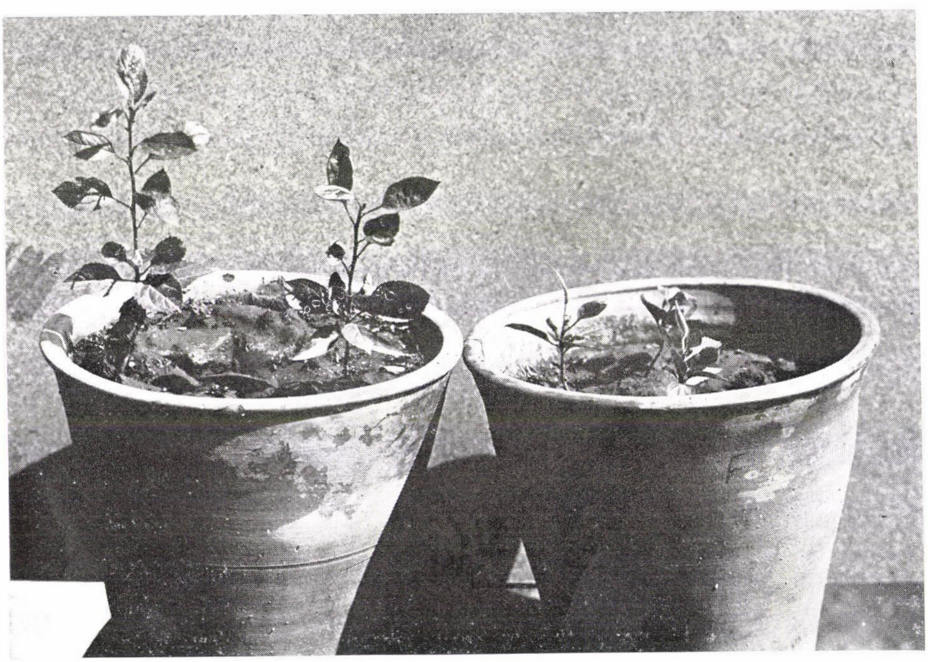

Fig. 5. The effect of soil mixing. Apple seedlings. From left to right: apricot soil, apple soil

Table 1

The effect of sterilizing chemicals
(The height of the seedlings in cm)

Chemicals	Apricot (Cgy 1652)	Apple (Golden del.)
Untreated	15.0	6.6
Hetron (dazomet) 10 pulv. 5.0 g/l soil	20.3	—
Hetron 16.6 gran. 3.2 g/l soil	22.0	9.8
Shell D–D 0.3 ml/l soil	17.0	8.3
Formaldehyde sol. 35% 3.0 ml/l soil	22.8	10.6
80°C 2hr	22.3	9.3
Sign. diff. 5%	4.6	1.5

Table 2

The effect of soil mixing
(The height of the seedlings in cm)

Soil proportions	Peach (Elberta)	Apple (Commerc.)
a) Peach soil : apple soil		
0 : 3	31.9	4.3
1.: 2	29.3	5.7
2 : 1	23.6	8.5
3 : 0	19.8	11.8
Sign. diff. 5%	6.8	3.7
b)	**Apricot (Commerc.)**	**Apple (Commerc.)**
Appricot soil 100%	14.9	8.3
Apple soil 100%	23.8	6.0
Sign. diff. 5%	2.8	2.2

*

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MULTI-LOCATIONAL BEHAVIOUR OF PROTEIN AND LYSINE CONTENTS IN HIGH YIELDING WHEAT VARIETIES NEWLY BRED IN INDIA

In multi-locational trials intended to compare a set of varieties with respect to specific characteristics, it is not sufficient just to compare the varietal performances averaged over the different locations. It has now been well established that varieties are to be judged on the basis of their stability and adaptability over a range of environments besides their average performance. This idea was originally introduced by Finley—Wilkinson (1963) and further pursued by Eberhart—Russel (1966).

Taking the cue from Eberhart and Russel, several studies of this type have been conducted by different authors on various crops, mostly on grain yield. But there is not much work of this type done on the quality characteristics of wheat. An attempt in this direction has been made in the present work, taking advantage of the large amount of material from multi-locational trials conducted with a wide range of improved varieties under the co-ordinated wheat improvement project in India.

The seeds of the different varieties entered in the All-India Co-ordinated Trials were tested for protein and lysine contents. The trials were basically multi-locational in nature and covered a large number of varieties evolved at various competing breeding centres. The purpose of these trials was to pick out the most suitable varieties of wheat for different zones from a number of competing entries on the basis of their performance at a number of locations in the zone. The details of the trials are given on the next page.

The protein content ($N \times 5.7$) of the grain was estimated by the macro-Kjeldahl method. Lysine was determined by an automated colorimetric method using a Technicon automatic lysine analyser. According to this method the determination of lysine in the hydrolysate is achieved by a continuous colorimetric determination of the CO_2 which is liberated on a mole per mole basis by the enzymatic decarboxylation of lysine using L-lysine decarboxylase. The method used in this study was basically the same as that described by Schraiberger—Ferrari (1960), a modification introduced in the present estimations being the use of phosphate buffer of pH 6 instead of water for diluting the sample and the exclusion of the overflow sampler intended to provide small aliquots of the diluted sample.

Statistical methodology. The data of protein and lysine contents were subjected to analysis of variance between locations (environments) and varieties (genotypes). Since only one composite sample for each variety from each centre was available for quality analysis, there was no error component for a formal statistical test of the significance of the interaction

Trial series	No. of locations from which samples were tested for		No. of varieties
	Protein	Lysine	
1. National trial (High Fertility: 120 kg N/ha) (All 5 Zones)	11	—	17
2. National Trial (Low Fertility: 80 kg N/ha) (All Zones)	8	8	25
3. Uniform Regional Trial (High Fertility: 120 kg N/ha) (North Western Plain Zone)	8	8	25
4. Uniform Regional Trial (Low Fertility: 80 kg N/ha) (North Western Plain Zone)	5	3	16
5. Uniform Regional Trial (High Fertility: 120 kg N/ha)	3	—	16
6. Uniform Regional Trial (High Fertility: 120 kg. N/ha) (Central Zone)	3	—	36

between locations and varieties. However, the interaction mean square between locations and varieties provided a valid error component for testing the location and varietal effects.

The study of stability and adaptability was restricted to those trial series for which data were available from at least 5 centres. The values of the regression coefficient and the residual mean square have been calculated for each variety based on the model

$$Y_{ij} = \mu_i + \beta_i I_j + \delta_{ij}$$

where Y_{ij} = the mean value of any given character for a variety i at location j expressed as the sum total of

a) the overall mean effect of the variety i,

b) contributions ascribable to the linear response of the ith variety to the jth location, and

c) a residual.

I_j = the index of the environmental conditions prevailing at the jth location.

If the experiments are conducted with a large number of varieties kept constant over all the locations, the mean value of all varieties in any location can reasonably be taken to give a relative measure of the environmental conditions in that location and hence I_j can be given by

$$I_j = \frac{1}{v}\sum_{i=1}^{v} y_{ij} = \frac{1}{nv}\sum_{i=1}^{v}\sum_{j=1}^{n} y_{ij}$$

where v is the number of varieties and n is the number of locations. β_i, the regression coefficient, estimated by

$$b_i = \sum_{j=1}^{n} y_{ij} I_j \Big/ \sum_{j=1}^{n} I_j^2$$

Table 1

Analysis of variance of protein percentage

Trial series	Source	D. F.	M S.	F.
NAT-HF-All. Zones	Locations	10	53.06	31.96*
All. Zones	Varieties	16	3.30	1.98*
	Error	160	1.66	
NAT-LF-All. Zones	Locations	3	164.13	117.24*
	Varieties	24	2.62	1.87*
	Error	72	1.40	
URT-HF-N. W. P.	Locations	7	79.88	36.71*
	Varieties	24	4.39	8.93*
	Error	168	0.49	
URT-LF-N. W. P.	Locaions	4	36.91	67.11*
	Varieties	15	2.18	3.93*
	Error	60	0.55	
URT-LS-N. W. P.	Locations	5	38.84	65.83*
	Varieties	15	1.84	3.09*
	Error	75	0.59	
URT-HF-N. E. P.	Locations	2	55.52	66.89*
	Varieties	15	1.12	1.34
	Error	30	0.83	
URT-HF-Cen. Zone	Locations	2	195.54	257.28*
	Varieties	35	1.38	1.81*
	Error	70	0.76	

* Significant at the 5% level

indicates the pattern of adaptability of the variety and $\sum_{j=1}^{n} \frac{\delta_{ij}^2}{n-2}$, the residual mean square, measures indirectly the stability of the variety. A variety with a larger residual mean square would fluctuate more widely around the response line predicted by the value of b_i and its performance is likely to be less dependable.

After calculating the regression coefficients and residual mean squares as described above, the varieties are classified into 9 groups by first dividing the varieties into 3 groups of high, medium and low protein percentages and then dividing each group into 3 groups of high regression coefficient (>1.2), medium regression coefficient (between 0.8 and 1.2), and low regression coefficient (<0.8). The logic of this classification is that we may like to choose a variety with a high protein value and regression coefficient near to 1. The value of the regression coefficient indicates the slope of the line of response ot the variety to the environment. If b

Table 2

Analysis of variance of lysine percentage

Trial series	Source	D. F.	M. S.	F.
URT-HF-N. W. P.	Locations	7	0.1957	11.44*
	Varieties	24	0.1193	6.97*
	Error	168	0.0171	
URT-LF-N. W. P.	Locations	2	0.1850	3.56*
	Varieties	15	0.0347	0.65
	Error	30	0.0533	
URT-LS-N. W. P.	Locations	2	0.04	2.40
	Varieties	15	0.01	1.15
	Error	30	0.01	

* Significant at the 5% level

Table 3

Analysis of variance of lysine content (mg per 100 g of dry matter)

Trial series	Source	D. F.	M. S.	F.
URT-HF-N. W. P.	Centres	7	3.4384	92.43*
	Varieties	24	0.02172	6.830*
	Error	168	0.0372	
URT-LF-N. W. P.	Centres	2	3.1608	64.50*
	Varieties	15	0.0846	1.72
	Error	30	0.0490	
URT-LS-N. W. P.	Centres	2	2.9428	56.26*
	Varieties	15	0.0695	1.32
	Error	30	0.0523	

* Significant at the 5% level

is much below 1, the response line is nearly horizontal, which indicates that the variety is not responding to any improvements in the environment. This is not a satisfactory situation. If b is much above 1, the response line is very steep. The performance of such varieties improves faster with improvements in the environment; but their performance also falls faster with deterioration of the environment. A variety with b nearly 1 improves with the environment only as much as is expected on the average and this will be the type having wider adaptability.

Hence varieties with values of b nearly equal to 1 are to be preferred for wider application. All the varieties have been classified into 9 groups as shown in Tables 4 to 7. In each class the varieties are listed along with the value of the regression coefficients and residual mean squares. The instability indices (index of residual variation), obtained by dividing the individual residual mean square by the pooled residual mean square, are also given. Varieties with instability indices of less than 1 are thus more stable than the average and vice versa. In the selection of varieties we thus have to select the varieties in the upper middle cell and among them only varieties with a lower instability index.

It is observed from the analysis of variance and the value of the variance ratio (F) given in Tables 1 to 3 that for protein percentage the variations due to location are highly significant. Although the variations due to varieties are also significant, the former variation is of a comparatively higher magnitude than the latter. The same trend was observed in the case of the amount of lysine on a flour basis. In the case of lysine as a percentage of protein (lysine percentage) the variation due to location is again more pronounced than that due to the varieties, although not so much as in the case of protein percentage and lysine on a flour basis. It may be noted that out of the three trial series for which data on lysine were available, only the high fertility trial showed any significant varietal variation, whereas for the low fertility and late sown trials the variation due to varieties was not significant.

Tables 4 to 7 give the varieties of different trial series classified into 9 groups obtained by first dividing the varieties into 3 groups of high, medium and low values for protein percentage and then dividing each of these groups further into 3 groups of high, medium and low values for the regression coefficient. Along with each variety the value of the regression coefficient and the index of residual variation are also given. Tables 8 and 9 give the same for lysine percentage and the amount of lysine on a flour basis respectively.

It is seen in Table 4 that in the National High Fertility trial, the varieties MP-85, WG. 377 and UP. 215 come into the category of high mean value of protein with a near to unity regression coefficient. Among these three, WG. 377 shows a high index of residual variation and hence cannot be considered stable. The other two varieties have a high protein percentage with wide adaptability and stable performance.

The data for the varieties entered in the high fertility uniform regional trial in the North West Plain Zone given in Table 5 show that the varieties HD. 863—4, HD. 2024 and UP. 327 can be considered to be of high protein content with wide adaptability and fairly good stability. But HD. 1925 and UP. 310, although high in mean protein percentage, do not show enough stability of performance to be relied upon. Raj. 827, although it shows a high mean protein percentage, has a slightly steeper regression line indicating it to be not very suitable for inferior environments, while UP. 326, which has a high value for the mean protein percentage, shows a slightly flatter regression line indicating it to be less responsive to improvements in the environment.

Among the varieties entered in the low fertility uniform regional trial in the North Western Plain Zone, HD. 2021, Raj. 725, UP. 237, UP. 245 and WH. 102 come under the category of high mean protein values combined with wide adaptability and good stability, while HD. 1981, although high in mean protein, does not show good stability in performance (Table 6). UP. 328 with a steeper regression line and HD. 2020 with a relatively flatter regression line can be considered to be more suited for superior and inferior environments respectively.

The data for the late sown trial from the North Western Plains Zone given in Table 7 show that HD. 1981, HD. 1925 and UP. 332 have high mean protein values combined with good stability and adaptability. For the lysine percentage (Table 8) only one variety, namely EA. 222-1, comes under the high lysine group. But this variety shows a very flat regression line which indicates that there is little scope for improvement through the environment. Regarding the amount of lysine on a flour basis (Table 9), HD. 2024 and UP. 326 have high

Table 4

Classification of varieties with respect to mean protein content and regression coefficient. National trial high fertility — all zones

Reg. coefficient / Proten contents	High (>1.2)			Medium (0.8 to 1.2)			Low (<0.8)		
	Varieties	Reg. coeffi-cient	Index of residual variation	Varieties	Reg. coeffi-cient	Index of residual variation	Varieties	Reg. coeffi-cient	Index of residual variation
High (>14.12)				MP. 85	0.887	1.29			
				WG. 377	1.050	2.13			
				UP. 215	1.065	0.93			
Medium (13.49 to 14.12)				HP. 833	0.937	0.82	WL. 212	0.755	1.19
				HD. 2012	1.080	0.79			
				HD. 1941	1.075	1.73			
				HD. 1977	1.041	2.08			
				HD. 1982	1.154	0.48			
				UP. 310	1.066	0.71			
				UP. 328	0.830	0.53			
Low (<13.49)	HD. 1962	1.317	1.11	Raj. 821	0.958	0.48	K. Sona	0.677	0.44
				HP. 916	1.122	0.56			
				HD. 1999	1.122	1.03			
				ISW. 34	0.858	0.68			

Table 5

Classification of varieties with respect to mean protein content and regression coefficient.
Uniform Regional Trial-High Fertility-North Western Plains Zone

Reg. coefficient / Protein contents	High (>1.2)			Medium (0.8 to 1.2)			Low (<0.8)		
	Varieties	Reg. coeffi-cient	Index of residual variation	Varieties	Reg. coeffi-cient	Index of residual variation	Varieties	Reg. coeffi-cient	Index of residual variation
High	Raj. 827	1.252	1.14	HP. 863-4	1.038	1.39	UP. 326	0.844	0.42
(>13.62)				HD. 1925	0.880	1.79			
				HD. 2024	0.991	0.86			
				UP. 310	0.985	2.14			
				UP. 327	1.017	0.61			
Medium	WL. 334	1.244	1.05	HD. 1949	1.190	0.65	Raj. 832	0.789	0.76
(12.62 to 13.63)	HD. 1949	1.218	3.14	Raj. 821	0.912	0.72	K. 856	0.505	1.14
	HD. 1977	1.231	0.76	Raj. 829	1.158	0.67			
				UP. 315	0.974	0.93			
				UP. 319	1.101	0.47			
				UP. 328	1.017	0.35			
				WL. 212	1.005	0.44			
				WL. 227	1.181	0.69			
				WG. 377	0.804	1.77			
Low				HD. 2009	0.908	1.61	EA-222-1	0.762	0.44
(<12.62)				HD. 2028	1.059	0.34			
				K. Sona	0.994	0.74			

Table 6

Classification of varieties with respect to mean protein content and regression coefficient. Uniform Regional Trial-Low Fertility-North Western Plains Zone

Reg. coefficient / Protein content	High (>1.2)			Medium (0.8 to 1.2)			Low (<0.8)		
	Varieties	Reg. coeffi-cient	Index of residual variation	Varieties	Reg. coeffi-cient	Index of residual variation	Varieties	Reg. coeffi-cient	Index of residual variation
High	UP. 328	1.300	3.95	HD. 1981	0.986	2.64	HD. 2020	0.671	0.11
(>11.25)				HD. 2021	1.170	0.54			
				Raj. 725	1.188	0.36			
				UP. 237	1.187	0.25			
				UP. 245	1.040	0.27			
				WH. 102	1.133	0.18			
Medium				HD. 2037	1.021	1.57	UP. 236	0.662	0.89
(10.46 to 11.25)				Raj. 723	1.055	1.77	WL. 208	0.795	0.13
(10.46 ro 11.25)				WL. 303	1.060	0.28			
				K. Sona	0.964	0.41			
Low	WH. 101	1.203	.13				C. 306	0.557	2.28

Table 7

Classification of varieties with respect to mean protein content and regression coefficient.
Uniform Regional Trial-Late Sown-North Western Plains Zone

Reg. coefficient / Protein content	High (>1.2)			Medium (0.8 to 1.2)			Low (<0.8)		
	Varieties	Reg. coeffi-cient	Index of residual variation	Varieties	Reg. coeffi-cient	Index of residual variation	Varieties	Reg. coeffi-cient	Index of residual variation
High (>13.92)	HD. 1941	1.450	0.29	HD. 1925	1.156	0.85	HD. 1977	0.329	1.26
				HD. 1981	1.010	0.92	WL. 334	0.744	0.57
				HD. 2016	0.988	1.45			
				Raj. 832	1.142	1.53			
				UP. 332	0.813	.23			
Medium (13.22 to 13.92)	Sonalika	1.284	1.81	HD. 1962	1.008	0.46			
				Raj. 821	0.888	2.25			
				WL. 303	0.853	1.62			
				WG. 472	1.170	0.04			
				UP. 319	1.056	0.87			
Low (<13.22)	WG. 377	1.349	0.23				K. Sona	0.653	1.55

Table 8

Classification of the varieties with respect to mean lysine content and regression coefficient. Uniform Regional Trial-High Fertility-North Western Plains Zone

Reg. coefficient / Lysine content	High (>1.2)			Medium (0.8 to 1.2)			Low (<0.8)		
	Varieties	Reg. coeffi-cient	Index of residual variation	Varieties	Reg. coeffi-cient	Index of residual variation	Varieties	Reg. coeffi-cient	Index of residual variation
High (>2.81)							EA-222-1	0.405	0.00
Medium (2.63 to 2.81)	HD. 863-4	1.265	1.50	HD. 2024	0.859	0.50	HD. 2028	0.405	0.00
	HD. 1949	1.663	0.50				Raj. 832	0.031	1.00
	HD. 1977	1.611	0.50				UP. 326	0.352	1.00
	Raj. 821	1.304	2.00				UP. 328	0.401	0.00
	UP. 315	1.988	0.00						
	UP. 319	1.681	0.50						
	WL. 227	1.431	0.00						
	K. Sona	1.551	0.50						
	Raj. 829	1.243	0.50						
	WL. 212	1.213	0.00						
Low (<2.63)	WL. 334	1.783	0.50	HD. 1925	0.969	1.0	HD. 2009	0.763	0.5
	Raj. 827	1.225	1.00	HD. 1941	0.176	0.5	WG. 377	0.066	1.0
				UP. 310	1.198	0.0	K. 856	0.162	0.5
				UP. 327	1.034	0.0			

Table 9

Classification of varieties with respect to mean lysine content (mg per 100 g dry matter) and regression coefficient. Uniform Regional Trial-High Fertility-North Western Plains Zone

Reg. coefficient / Lysine content	High (>1.2)			Medium (0.8 to 1.2)			Low (<0.8)		
	Varieties	Reg. coeffi-cient	Index of residual variation	Varieties	Reg. coeffi-cient	Index of residual variation	Varieties	Reg. coeffi-cient	Index of residual variation
High (>370 mg)				HD. 2024	1.201	2.10			
				UP. 326	1.114	1.52			
Medium	HD. 1977	1.283	1.04	HD. 863-4	1.126	1.51	Raj. 821	0.563	1.25
(343 to 370 mg)	Raj. 829	1.349	0.51	HD. 1925	0.915	0.29			
	UP. 328	1.240	0.35	Raj. 827	0.863	2.77			
	WL. 227	1.300	0.38	Raj. 832	1.172	0.98			
				EA-222-1	0.901	0.68			
				UP. 310	0.949	1.38			
				UP. 319	0.899	1.48			
				WL. 212	1.068	0.19			
Low	HD. 1941	1.378	0.63	HD. 2009	1.034	1.59	HD. 1949	0.609	0.39
(<343 mg)	HD. 2028	1.259	1.52	UP. 327	0.896	0.44	UP. 315	0.666	0.55
				WL. 334	0.894	1.96	K. 856	0.568	0.34
				WG. 377	0.995	0.59			
				K. Sona	0.916	0.64			

mean values with near to unity regression, but both suffer from a high index of residual variation. The choice, therefore, falls upon varieties with medium amounts of lysine, like HD. 1925, EA. 222—1 and WL. 212.

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RELATIONSHIP OF EVAPOTRANSPIRATION WITH PAN EVAPORATION AND EVALUATION OF CROP COEFFICIENT

Soil moisture utilisation in a cropped field is a result of several interactions, of which the weather parameters (Pruitt 1960), the crop and its growth stages (Prashar—Singh 1963) are known to be important. While the weather parameters have a dominating influence on the rate of moisture use per day for a given crop, the growth stages of the crop seem to have a modifying effect. In the estimation of the evapotranspiration of crops under different irrigation projects in India, the use of Et/Eo ratios at different growth stages has been advocated (Anonymous 1971) and one such estimation for the Nagarjunasagar project has recently been computed (Anonymous 1975). In India several studies have been reported on Et/Eo ratios for wheat and other crops (Prashar—Singh 1963, Singh 1968). Among the empirical estimations of consumption, the Blaney Criddle formula has been widely used and the crop coefficient (K) is regarded as a crucial parameter, to be estimated through experimentation (Jensen 1966, Erie *et al.* 1968).

Data for the purpose of computing Et/Eo ratios and the crop coefficient (K) have been drawn from the statistical studies conducted between 1969 and 1975, which included four experiments on wheat, three on sorghum, two each on groundnut, sesame, safflower, mustard, sunflower, soybean and castor, and one each on corn, pearl millet, cotton and chickpea crops. All these crops were raised during the winter season, except the sorghum and pearl millet, which were raised during the summer. There was no ground water contribution on any of the experimental sites.

The evapotranspiration of these crops was estimated by the gravimetric method by taking samples before and after irrigation up to a depth of 60 cm in three layers consisting of 0—15 cm, 15—30 cm and 30—60 cm. The crop coefficient factor (K) was estimated for

Table 1

Periodical Et/Eo ratios of different crops

Crop age in days	November				
	Wheat	Corn	Groundnut	Sesame	Safflower
0— 15	—	0.62	0.62	0.49	0.61
15— 30	0.70	0.71	0.61	0.57	0.62
30— 45	0.77	0.78	0.72	0.62	0.64
45— 60	0.81	0.80	0.65	0.71	0.62
60— 75	0.77	0.89	0.78	0.79	0.68
75— 90	0.53	0.82	0.68	0.62	0.66
90—105	—	0.50	0.51	0.41	0.37
105—120	—	0.53	0.41	—	0.33
120—135	—	—	0.38	—	0.30
Seasonal values	0.72	0.71	0.60	0.60	0.54

wheat, corn, sorghum and pearl millet using the Blaney Criddle formula (U = Kf). Pan evaporation was measured from a nearby observatory located within the campus. The values of Et/Eo and the K factor are given with respect to the optimum moisture regime for each of these crops.

Table 1 shows the data on Et/Eo ratios of 13 crops grown between November and April.

The seasonal Et/Eo ratios of corn and wheat crops were the highest, with more than 0.7 under optimum soil moisture regimes. These ratios ranged between 0.60 to 0.62 for castor, cotton, sunflower, sesame and groundnut, while they were between 0.54 and 0.60 for sorghum, pearl millet, safflower, mustard, soybean and chickpea crops. The Et/Eo ratios in relation to the crop growth stages have shown marked differences in all these crops. The highest ratio was observed between 45 to 60 days with respect to wheat (0.81), pearl millet (0.75), sunflower (0.74), mustard and soybean (0.73) crops, while it was between 60 and 76 days with respect to corn (0.89), sesame (0.79), groundnut (0.78), sorghum (0.72), safflower (0.68) and chickpea (0.67). However, the cotton and castor crops exhibited a peak ratio between 30 and 45 days ranging from 0.71 to 0.78 respectively. In general short duration crops showed an early peak in the Et/Eo ratios compared to crops of relatively longer duration, with the exception of cotton and castor. Similar ratios of about 0.8 to 0.84 were reported by Pruitt (1960, 1964, 1966) and McIlory—Angus (1964).

Table 2 shows the K factor from the Blaney Criddle formula with respect to four crops.

The crop coefficient (K) showed variations at different growth stages similar to that of the Et/Eo ratio. The seasonal K factor for different crops varied between 0.62 and 0.74. These trends are in agreement with the values of 0.87 for sorghum and 0.99 for wheat under Arizona (USA) conditions (Erie *et al.* 1968). As concluded by Pruitt (1966), such Et/Eo ratios of crops are likely to be useful as a practical tool for estimating the seasonal evapotranspiration where the pan evaporation data are available.

between November and April

sowing						January sowing	
Mustard	Sunflower	Soybean	Castor	Cotton	Chickpea	Sorghum	Pearl millet
0.44	0.63	0.45	0.74	0.81	—	0.47	—
0.50	0.65	0.55	0.72	0.69	0.60	0.45	0.43
0.63	0.68	0.59	0.78	0.71	0.50	0.61	0.61
0.73	0.74	0.73	0.69	0.62	0.53	0.67	0.73
0.53	0.62	0.60	0.59	0.62	0.67	0.72	0.51
0.45	0.52	0.49	0.45	0.55	0.51	0.66	—
—	0.39	—	0.36	0.47	0.36	0.46	—
—	—	—	—	0.32	—	—	—
—	—	—	—	—	—	—	—
0.55	0.60	0.57	0.62	0.60	0.57	0.56	0.57

Table 2

Fortnightly computed crop coefficient values (Blaney Criddle K values) for wheat, corn, sorghum and pearl millet

Crop age in days	November sowing		January sowing	
	Wheat	Corn	Sorghum	Pearl millet
0— 15	0.52	0.55	0.42	—
15— 30	0.57	0.61	0.49	0.50
30— 45	0.65	0.62	0.61	0.81
45— 60	0.79	0.64	0.81	0.93
60— 75	0.70	0.92	0.69	0.73
75— 90	0.48	0.81	0.71	—
90—105	—	0.61	0.69	—
105—120	—	0.60	—	—
Seasonal values	0.62	0.67	0.68	0.74

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FIVE YEARS' RESULTS OF INVESTIGATIONS INTO POWDERY MILDEW IN WHEAT AT MARTONVÁSÁR (1971—1975). III. EXAMINATION OF RESISTANCE IN VARIETIES

Ever since the sixties powdery mildew infection in wheat has occurred to a greater or lesser extent every year in Hungary. This has made it necessary to examine the possibilities of control. One possible method is to produce resistant varieties and introduce them into commercial production. This requires a thorough knowledge of the resistance of the varieties to the pathogen population and to its different races.

It is a fact well known from the literature that sometimes the same variety is considered to be resistant by one author and susceptible by another. This can be partly explained by the possibly varying race composition of the pathogen population in the countries where the authors carried out their investigations. This sort of contradiction occurs less frequently when the resistance of varieties to races is examined. Information on the responses given by wheat varieties to infection by various powdery mildew races can be obtained from works by NOVER—LEHMANN (1964), LEIJERSTAM (1965), SHMILYAKOVITS (1966), SZUNICS—SZUNICS (1970), MRÁZ (1971), JORGENSEN—JENSEN (1972), KUNOVSKY *et al.* (1973) and SZUNICS (1976).

Powdery mildew was collected from various varieties sown on the experimental area. The races were identified by the method of NOVER (1957). The varieties examined were raised in wooden boxes under glass isolation cabinets. The plants were infected with each race of the pathogen separately before the second leaf appeared, then 10—12 days after the inoculation the type and percentage of the infection were established. During the experiment the temperature was between 16 and 20°C, and the relative humidity of the air ranged from 50 to 90%. A supplementary illumination of 4000 lux was provided for nine hours a day.

The data obtained are presented in tables. The type of infection for a few plants of certain varieties whose data differ markedly from the average is given in brackets. In some places in the column for the type of infection two figures are given (e.g. 1—4), indicating that the varieties in question do not react uniformly to infection by the given races.

The wheat varieties grown at present in Hungary are susceptible to most of the powdery mildew races examined. This applies to the Hungarian (Table 1) and partly to the Soviet varieties (Table 2). The GDR samples, Neuzucht and RPG 14/44 (NOVER 1957), derived from crossing wheat with rye were resistant to certain races and susceptible to others. Of the varieties originating from England some are resistant, some become infected to a greater or lesser extent by certain races, and others are susceptible (Table 3). In the genealogy of TP 114/65A *T. timopheevi* is present, in that of TP 226 *T. carthlicum* and in TP 309/A *T. dicoccum* (SHMILYAKOVITS 1966, WOLFE 1967, LEIJERSTAM 1972, JORGENSEN—JENSEN 1972, JAKUBTSINER 1974).

Of the American varieties Arthur, and of the Yugoslav varieties Sava proved to be resistant. Moisson and Libellula were found to be susceptible to all races but No. 14 (Table 4).

The 28 varieties listed in the paper can be divided into four groups on the basis of resistance at the germ stage:

1. Varieties susceptible to all races. Most of the varieties commercially grown in Hungary can be placed in this group: Fertődi 293, GKF-2, Martonvásári 1, Martonvásári 3, Bezostaya 1, Rannyaya 12 and Mironovskaya-Jubileinaya 50. Bánkúti 1201, Fleischmann 481, Odesskaya 51 and Sturdy may also be mentioned here.

2. Varieties which may be regarded as a population from the point of view of resistance. They do not give definite responses to the different races. All types from resistant to susceptible can be found among them. TP 226 and Atlas 66 are examples of such varieties.

3. Varieties resistant to some races and susceptible to others. VAN DER PLANK (1968) calls this phenomenon vertical resistance. This group includes Avrora, Kavkaz, Neuzucht, RPG 14/44 and Zlatna Dolina. Arthur, TP 114/65A and Sava are worthy of separate mention since they are practically resistant to all but two races, and are thus suitable for use in resistance breeding.

4. Varieties resistant to all races are seldom found. The strains TP 309/A and TP 315/2 proved to be resistant to the 14 races examined and, as resistance factors, may be valuable crossing partners in breeding.

Our results confirm the observation made by GAUMANN (1954), STAKMAN—HARRAR (1957), STEPANOV (1962) and KIRÁLY (1969) that resistance is a relative conception rather than a universal property of the variety, since it is only displayed against certain races.

All in all, it can be established that the wheat varieties grown at present do not provide sufficient protection against damage caused by powdery mildew. Among the foreign varieties there are some which are less susceptible or even resistant, but introducing them into commercial production under Hungarian conditions would involve considerable risk since they have a number of unfavourable characteristics.

For this reason it is imperative to produce resistant varieties. Some of the varieties discussed could be used in breeding as resistant basic material.

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Table 1

Infection of Hungarian wheat varieties

Races	Varieties					
	Bánkúti 1201		Fleischmann 481		Fertődi 293	
	infection		infection		infection	
	type	%	type	%	type	%
0	3—4	98.3	3—4	91.5	3—4	87.6
2	4	96.0	3—4	100.0	3—4(1)	92.9
3	3—4	78.3	3—4	75.5	3	52.1
4	4	90.6	3	100.0	3—4(0)	67.6
7	4	86.0	4	94.5	3—4(1)	77.2
9	3—4	67.2	2	87.5	3	73.6
13	3	91.3	3—4	83.0	3—4(1)	60.2
14	3—4	71.4	3—4	62.0	3—4(1)	71.4
18	4	94.6	4	100.0	4	93.7
21	3	46.0	3	37.7	3—4(0)	36.3
27	4	100.0	3—4	100.0	3—4	95.7
30	3—4	94.5	3	88.0	2	79.1
46	3—4	67.3	3—4	98.3	3—4(0)	78.3
52	3—4	76.0	3—4	69.3	3—4(1)	70.4

Table 2

Infection of Soviet wheat varieties

Races	Varieties					
	Bezostaya 1		Rannyaya 12		Avrora	
	infection		infection		infection	
	type	%	type	%	type	%
0	3—4	51.3	3—4	57.3	1(0)	11.3
2	3—4	100.0	3—4	100.0	3—4	100.0
3	3—4	70.9	4	68.3	1(0)	0.8
4	3—4	93.0	3—4	98.5	3—4	97.1
7	3—4	87.7	1	83.5	1	2.9
9	4	33.1	4	43.3	3—4	17.6
13	3—4	78.1	3—4	73.0	1(0)	0.1
14	2	20.0	3—4	53.6	0	0.0
18	4	96.9	4	97.7	1(0)	1.3
21	3	33.8	3—4	40.0	0—1	0.4
27	3—4	100.0	3—4	100.0	3—4	95.0
30	2—3	86.2	2—3	87.0	1(0)	0.9
46	3—4	61.7	3—4	72.7	1	1.7
52	4	70.8	3—4(0)	40.0	3—4	28.7

by various powdery mildew races

Kiszombori 1		GKF-2		Martonvásári 1		Martonvásári 3	
infection		infection		infection		infection	
type	%	type	%	type	%	type	%
3—4	90.7	3—4	91.4	3—4	42.2	3	47.3
3	95.0	3	100.0	3—4	100.0	3—4	100.0
3—4	75.3	4	75.4	4	72.0	4	92.0
3—4	93.3	3—4	91.4	3—4	100.0	3—4	100.0
3—4	90.6	4	91.6	4	61.8	3—4	81.4
3—4	78.0	3—4	50.7	3—4	30.0	3—4	32.9
3—4(1)	60.8	3(0)	42.0	3	61.0	3—4	61.0
2	16.5	2—3	35.8	1—3	46.4	3	46.9
4	97.0	4	50.8	3—4	71.4	4	85.3
3	34.5	4	37.5	4	35.0	4	25.3
3—4	100.0	3—4	96.4	3—4	100.0	3—4	100.0
2	83.8	3—4	86.6	2—3	78.8	2—3	70.6
3—4	88.0	3—4	95.3	3	64.6	3—4	76.0
4	54.0	4	66.6	4	100.0	4	100.0

by various powdery mildew races

Kavkaz		Mironovskaya 808		Mironovskaya-Jubileinaya 50		Odesskaya 51	
infection		infection		infection		infection	
type	%	type	%	type	%	type	%
1—2	4.8	3—4	93.5	3—4	81.8	3—4	88.4
3—4	100.0	3—4	100.0	3—4	100.0	3—4	100.0
1(0)	0.2	3—4(1)	72.7	4	74.5	4	70.0
3—4	93.8	3—4	93.3	3—4	97.5	4	88.0
0—1	0.9	3—4	91.3	3—4	84.2	4	70.7
4	25.0	4	33.4	3—4	62.7	3—4	61.4
1(0)	0.1	3(2)	38.0	3	73.8	3	55.0
0	0.0	2	36.4	3	68.0	3	32.6
0—1	0.6	4	94.0	4	92.7	4	90.0
0—1	0.2	4	27.0	4	38.8	4	20.4
3	98.3	3—4	100.0	3—4	100.0	3—4	100.0
1—2(0)	13.3	3	84.1	2(3)	80.1	3	91.4
1(0)	0.4	3—4	93.3	3	91.4	3—4	90.0
4	74.0	4	74.6	4	53.0	4	74.0

Table 3

Infection of English and GDR wheat varieties

Races	Varieties					
	TP 114/65A		TP 226		TP 309/A	
	infection		infection		infection	
	type	%	type	%	type	%
0	0	0.0	1—2(0)	61.8	0	0.0
2	0—2	0.5	3—4(0)	73.9	0—1	0.2
3	0—1	0.3	4(1)	41.5	0(1)	0.1
4	0—1(4)	2.7	4(0)	64.0	0	0.0
7			3—4	85.3	0(1)	0.1
9	4(0)	35.1	4(1)	37.7	0	0.0
13	0(2)	0.1	0—2	14.0	0	0.0
14			0—3	3.8	0	0.0
18			3—4	75.7	0	0.0
21	0—1	0.2	4	27.5	0—3	0.5
27			0,3,4	43.0	0—1(4)	6.4
30	1—2	3.9	3—4(0)	66.6	0	0.0
46	0—2	0.8	3—4	76.9	0	0.0
52	3—4	53.3	4	72.0	0	0.1

Table 4

Infection of American, French, Yugoslav and Italian

Races	Varieties					
	Atlas 66		Arthur		Sturdy	
	infection		infection		infection	
	type	%	type	%	type	%
0	3—4(0)	75.0	0—1	0.2	4	64.6
2	3—4	100.0	0—4	5.7	3—4	100.0
3	1—2	29.3	0(1)	0.1	4	74.0
4	1—4	60.4	0—3	8.6	3—4(1)	90.0
7	1—2(0)	40.2	0(1)	0.2	4	96.9
9	2—4	46.3	1—2(0)	4.1	3—4	60.0
13	2	25.0	1(0)	0.8	3(0)	4.7
14	1—2(3)	21.8	0—1	0.5	1—3	2.2
18	1—2	62.6	1(0)	1.5	3—4	82.6
21	4	14.8	1	3.5	0—2	4.4
27	3	92.0	1—2(0)	4.4	3—4	72.8
30	3	94.1	1—3	33.4	3	98.6
46	3—4(0)	84.6	0—1	4.6	3—4	96.0
52	3—4	54.2	2—3(0)	35.1	4	72.7

by various powdery mildew races

TP 315/2		TL 340/15		Neuzucht		RPG 14/44	
infection		infection		infection		infection	
type	%	type	%	type	%	type	%
0	0.0	3–4	60.0	0–1(2)	6.7	0–1	3.0
0	0.0	3–4	95.7	4	89.2	3–4	78.5
0	0.0	3	61.4	0(1)	0.4	0–1	0.2
0	0.0	3	96.0	3–4	84.4	3–4	93.0
0	0.0	3–4	72.3	0–1	1.3	0–1	0.3
0	0.0	3–4	70.8	4	52.1	4	30.8
0	0.0	2	36.7	0–1	0.8	0–1	0.1
0	0.0	2–3(0)	15.5	0	0.0	0	0.0
0	0.0	4	80.9	1(0)	1.1	0–1(2)	3.0
0	0.0	4	17.7	1,2,4	11,0	4	17.7
0	0.0	3–4	100.0	4	70.0	3–4	83.3
0	0.0	1–3	87.5	0–1	1.0	0	0.0
0	0.0	3–4	89.2	1–2	1.7	0–1	0.1
0	0.0	3–4	92.0	4	88.7	4	71.8

wheat varieties by various powdery mildew races

Moisson		Sava		Zlatna Dolina		Libellula	
infection		infection		infection		infection	
type	%	type	%	type	%	type	%
4	89.1	1(0)	11.1	1(3)	37.6	3–4	69.0
4	100.0	0–1	2.1	2(0)	9.2	4	77.1
3–4	67.7	0	0.0	0	0.0	3	58.5
3–4	92.7	1(0.2)	27.6	1(3)	34.2	1–2	31.8
4	88.4	0(1)	0.1	0–1	1.9	3–4(1)	65.0
3–4	55.7	1(0.4)	7.2	1–2	21.3	3	46.8
3–4	75.3	0–2	7.0	1	24.9	1–2	30.7
1–2(0)	1.4	0	0.0	0–1	0.6	0–1(2)	0.8
4	90.7	0–2	4.9	1	18.4	1–2	73.3
4	35.4	0(1)	0.1	0–1	1.3	4	30.3
3–4	61.6	1	2.8	1	22.0	3–4	66.0
3–4	58.0	0–1	0.4	1–3	30.8	2	48.4
4	67.1	0–1	0.4	0–1	5.1	4	80.0
4	50.6	0–2	4.3	0–2	4.2	3–4	55.1

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THE INFLUENCE OF RESTRICTED FEEDING ON EGG PRODUCTION, FERTILITY, HATCHABILITY AND VIABILITY OF DANDARAWI LAYERS

Quantitative food restriction trials have been widely used to reduce the cost of feeding and/or to improve laying performance. Restricted feeding during the rearing period may result in increased egg production and feed efficiency, but may delay sexual maturity and increase the susceptibility to disease during the rearing period (LEE *et al.* 1971a, b). HOLLAND—GOWE (1961) believe that it acts as a mild stress which stimulates greater development of the endocrine glands and the bird responds during the laying period by achieving a higher production and greater resistance to environment stress.

Feeding medium weight layers to appetite is not justifiable, hence hens can regulate their body weight on a controlled feeding system without affecting egg production (QUISENBERRY *et al.* 1974). WELLS (1974) determined the food consumption between 38 and 40 weeks of age, then held it constant at that level till the age of 76 weeks. He found that the level of restriction achieved was about 10—12%, hence consumption was increased by the full-fed layers. SUPRAMANIAM (1974) observed that when growth has stopped and egg production slowly falls off after its peak, the food intake remains fairly steady. The apparent surplus of food consumed appears to be used in the deposition of fat in the abdomen and the liver, which may result in the depression of egg production and raises mortality.

The present study was carried out to compare the performance and viability of full-fed and restricted-fed Dandarawi pullets.

240 Dandarawi pullets at 36 weeks of age, plus 24 Rhode Island Red cocks at 50 weeks of age were equally divided into 3 treatments with two groups in each. T1 was full-fed and considered as a control, T2 was restricted to 85% and T3 was restricted to 75% of the control. Birds of all groups were adequately fed on the same diet before the beginning of the experiment, which lasted for 14 weeks. During the experimental period, all groups were fed the same diet, the formation of which is presented in Table 1. The birds in treatment T1 were fed *ad libitum*, their weekly consumption was measured and the predetermined fraction of this amount was fed to the restricted flocks in the following week as a daily food allowance. The food consumption of each cock was estimated as 3/2 of hen consumption in the same pen.

The pullets were weighed at the beginning and end of the experimental period and mortality was recorded. Layers were trapenested and their eggs were weighed daily.

A ten-day collection of settable eggs was incubated at the beginning of the experiment and at the end of each month for fertility and hatchability estimates. The specific gravity of the eggs was measured on the same occasions, but using newly laid eggs of two days collection. They were given scores (0—8) according to USDA random sample test tables (1969), the higher the score, the thicker the shell.

Food and metabolised energy consumption, protein and calcium intake of each hen per day were estimated. The egg production rate was estimated on the basis of hen-day percentage and feed conversion efficiency as grams of feed per gram of eggs. Gross energetic efficiency was estimated according to SUPRAMANIAM (1974) as follows

$$\left(\frac{\text{g eggs produced} \times 1.66}{\text{g feed consumed} \times \text{K cal/g feed}}\right) \times 100 \,.$$

Analysis of variance was performed on the replicate data, those expressed in percentage below 30 or above 70 were first transformed to arc sin $\sqrt{\text{percentage}}$ as outlined in SNEDECOR—COCHRAN (1967).

Body weight and mortality. As evidenced by Table 2, body weight loss was significantly higher in the group which was restricted to 75% of the full-fed group. Although the means of initial body weight did not differ significantly among the three groups, T2 lost 157 grams and T3 lost 214 grams compared with 40 grams for T1 throughout the 14 weeks of the experimental period. This result contradicts that of ABOUL-SEOD *et al.* (1970), who found no significant differences in body weight between full-fed and restricted-fed (85 and 70%) Fayoumi and R. I. R. hens.

The mortality percentage (Table 2) was at the lowest level (1.1%) in the group which received 85% of the full-fed group, but did not differ significantly from that of the control group (2.2%). Mortality increased significantly in T3 where it reached 11.4%. QUISENBERRY *et al.* (1974) found that mortality was not affected when a well balanced medium density diet

Table 1

The composition of the basic ration

Ingredients	%
Yellow corn	40.5
Wheat bran	20
Decorticated cottonseed meal	10
Protelan	10
Rice bran	10
Blood meal	3
Limestone	5.5
Common salt	0.5
Mineral mix[1]	0.4
Vitamin mix[2]	0.1
Calculated analysis[3]	
Metabolizable energy (Kcal/1 kg)	2538
Crude protein (%)	16.3
C/P ratio	155.6
Calcium (%)	2.175

[1] Each kg contains: 990.15 g sodium chloride, 6.08 g ferrous sulphate, 1.98 g ferric sulphate, 0.99 g, potassium chloride, 0.20 g copper oxide, 0.2 g, manganese sulphate, 0.1 g zinc oxide

[2] Vitamin mix.: Vit. A 2200 I. U., Vit. D_3 269 I. C. U. and 55 mg terramycin per gram

[3] Values were calculated according to Anwar

Table 2

Means of different variables measured during

Variable \ Treatment	Initial body weight (g)	Final body weight (g)	Body weight loss (g)	Mortality	Rate of laying (hen/day)	Average daily egg production (g/bird/day)
T_1 (Control ad lib.)	a	a	a	a	a	a
	1130	1090	−40	2.2	43.9	17.4
	a	b	b	a	a	a
T_2 85%	1120	963	−157	1.1	42.1	16.8
	a	b	c	b	b	b
T_3 75%	1160	946	−214	11.4	31.5	13.1

(a, b, c) Any two means not having the same letter are significantly different at the 5% level

* Based on food cost and egg price

was restricted by 5 or 10%, but it tended to increase when feed restriction was partially offset by a higher dietary density.

Rate of laying and egg weight. The rate of laying, as measured by percentage hen-day production and average daily egg production (Table 2), did not differ significantly between T1 and T2, but was significantly lower in T3. On average, the daily egg production for each hen was 17.4 grams in T1, 16.4 grams in T2 and 13.1 grams in T3. Weekly changes in egg production (Table 3) were highly significant in all groups, but without a special trend, hence the mean squares between periods were linear, quadratic and their deviations were also highly significant (Table 5). The highest production was 60.2% for T1 in the fifth week, 54.8% for T2 in the eleventh week and 52.0% for T3 in the first week of the experiment. The lowest production was reached in all groups during the last two weeks of the experiment, when the hens were faced with the unfavourable weather of May.

The average egg weight ranged from 39.2—39.9 grams in all groups and the differences between them were not significant (Table 2). However, the differences in total egg weight produced were highly significant due to treatments, and the period effect was mainly linear (Table 5).

The results of the present study demonstrated that restriction of food to 85% of the *ad libitum* amount did not change the egg size and there was no significant decline in egg production. Aboul-Seod *et al.* (1970) found no significant differences in egg production between full-fed and 85% restricted-fed Fayoumi and R. I. R. hens, and although 70% restricted hens laid less eggs, the difference was still not significant. Abderrahim (1966) reported no significant differences in egg number among full-fed, 85% and 70% restricted-fed Fayoumi and Alexandria hens, but significant differences were reported in the egg weights of the Alexandria.

Restricted-fed birds during rearing were at a disadvantage in egg production to a fixed time because of their delay in maturity, but showed a higher production for equal periods after maturity compared with full-fed birds (Lee *et al.* 1971a, b). No significant differences in average egg weight were reported at the same chronological age, but because the egg production curve was displaced, there was a change of one gram at a fixed time. MacIntyre—Gardiner (1964)

the experimental period as affected by restriction of food

Average egg weight (g)	Daily food consumption (g)	Protein intake (g/bird/day)	M. E. consumption (Kcal/bird)	Calcium intake (g/bird/day)	Feed efficiency (g food/g egg)	Gross energetic efficiency %	* Weekly return/100 birds (L. E.)
39.2	a	a	a	a	a		
39.2	110	17.9	258.9	2.22	6.3	10.3	5.81
	b	b	b	b	b		
39.7	93	15.2	220.8	1.89	5.5	11.8	6.10
	c	c	c	c	a		
39.9	83	13.4	195.4	1.67	6.3	10.3	4.19

Table 3

Effect of restricted feeding on rate of laying, Egg weight and food consumption of Dandarawi pullets

Weeks	% Rate of hen/day production			Egg weight (g)			Food consumption (g/bird/day)		
	T_1 (ad lib.)	T_2 (85%)	T_3 (75%)	T_1	T_2	T_3	T_1	T_2	T_3
W_0	55.7	51.3	52.0	39.1	41.0	39.4	120.3	—	—
W_1	48.4	44.5	40.9	38.0	41.1	40.5	100.2	102.8	90.8
W_2	45.4	42.1	29.5	37.4	40.0	42.9	110.2	84.5	75.3
W_3	53.0	37.5	23.2	41.8	41.5	43.3	113.3	93.5	83.5
W_4	60.2	46.3	37.0	40.1	38.7	38.6	108.7	96.3	86.0
W_5	46.6	46.1	44.8	38.2	39.4	41.3	108.7	92.5	82.3
W_6	45.9	48.1	45.7	38.3	36.8	39.2	95.4	92.5	82.3
W_7	40.0	43.9	35.2	38.9	40.2	40.0	95.4	81.3	69.5
W_8	40.2	38.2	29.4	40.1	39.8	36.2	109.9	80.7	72.4
W_9	39.6	34.1	24.6	43.5	39.9	41.7	86.3	92.2	80.8
W_{10}	45.2	54.8	38.1	43.4	39.5	39.2	91.1	77.4	66.9
W_{11}	44.5	44.8	21.3	41.4	40.6	38.5	91.9	90.2	66.6
W_{12}	23.1	35.4	9.8	38.1	38.6	37.1	101.6	75.8	69.3
W_{13}	24.8	23.5	17.1	37.4	37.2	36.6	95.2	84.9	75.4
Mean	43.9	42.1	31.5	39.2	39.7	39.9	110	93	83

Table 4

Effect of restricted feeding on specific gravity, fertility and hatchability percentage

Variable / Periods	Specific gravity*			Fertility %**			Hatchability %		
	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3
P_1	7.6	7.3	7.5	89.5	83.8	82.0	77.2	70.0	75.8
P_2	7.2	6.4	7.0	87.2	81.1	84.0	84.0	81.4	88.6
P_3	7.4	6.0	6.5	75.6	75.0	79.0	80.8	81.4	73.5
P_4	6.9	5.8	6.4	83.4	80.5	88.8	68.7	57.2	76.1
P_5	6.1	5.4	4.8	73.4	78.8	88.8	73.8	87.1	91.7
Mean	7.1a	6.3a	6.3b	81.8a	79.8a	85.9a	76.9a	75.4a	81.1a

* Based on 785 eggs
** Based on 3520 eggs

(a, b) Any two means not having the same letter are significantly different at the 5% level

Table 5

Analysis of variance for egg number, egg weight, food consumption specific gravity, fertility and hatchability percentage

S. of V.	d. f.	M. S. for		
		Egg No.	Total egg wt.	Food consum.
Between Reps	2	6120**	12.97**	9.3
Between periods (p)	13	4057**	7.00**	137.2**
Linear	1	4062**	9.52**	24.0**
Quadratic	1	1522**	1.35	30.4**
Deviation	11	4295**	7.28**	7.5
Treatments (T)	2	10847**	14.0**	518.2**
P × T		249	1.11	2.5
Error	41	368	0.64	4.2

S. of V.	d. f.	M. S. for		
		Sp. g.	Fer.	Hatch.
Between periods	4	301.0**	62.0*	151.5**
Between treatments	2	108.0**	65.0	84.4
Error	778(23)	0.42	23.3	36.1

(23) Represents error d. f. for fertility and hatchability percentage
* Significant at the 5% level
** Significant at the 1% level

showed that the duration of food restriction affects the time of peak production, the height of the peak and the rate of laying.

Food consumption, efficiency and cost. As may be expected, the food consumption was significantly different for each of the three treatments (Tables 2 and 5). The daily food consumption per hen ranged from 90.1—120.3 grams in the case of full-fed groups (Table 3). The food consumption of the control group fluctuated weekly, as accordingly did the food offered to the other two groups in the following weeks. It was estimated that each full-fed hen consumed, on the average, 258.9 Kcal metabolized energy, 17.9 g protein and 2.22 g calcium per day (Table 3).

The efficiency of food utilization, expressed as grams of food consumed per gram of eggs produced or as gross energetic efficiency, showed that the 85% restricted pullets made the most efficient use of food. They achieved a feed efficiency of 5.5% and an 11.8% gross energetic efficiency compared with 6.3 and 10.3%, respectively, for both the 75% restricted and the full-fed pullets.

The increasing feed efficiency reduced production costs. The weekly return based on the food and egg prices prevailing at the time of the experiment showed that the 85% restricted group achieved a financial advantage over the control (Table 2). The saving in food cost of the

75% restricted group was outweighed by the associated loss in egg production. OHH—PARK (1974) reached a similar conclusion, indicating that restricted-fed egg type stocks during rearing may increase the relative profit by 10—13%.

QUISENBERRY *et al.* (1974) counterbalanced the feed restriction by increasing the diet density. A feed restriction of 5—10% from the ad libitum amount reduced production costs. Egg production and feed efficiency strongly favoured the intermediate density diet. The highest density diet was equal to the ad lib. in egg numbers and was superior in egg size and feed efficiency but there was an increase in mortality. LAGERVALL (1974) found that skip-a-day feeding of laying type chickens during rearing did not affect the rate of lay or feed utilization.

Specific gravity of eggs. As shown in Tables 4 and 5, the eggs of restricted-fed pullets had significant shell thickness, still considered good, hence the upper limit score reported in USDA random sample tests (1969) was 4.58 for egg type stocks. Egyptian chickens are well known for their good shell thickness; however, increasing the calcium level in the restricted diet may stabilize this character.

MILLER—SUNDE (1975) found that shell rigidity was not affected by feeding and lighting restrictions during the growing period. WELLS (1974) observed a small improvement in the shell thickness when the layer's food was restricted.

Fertility and hatchability. The highest mean fertility (85.9%) and the highest mean hatchability of fertile eggs were obtained from the 75% restricted-fed pullets (Table 3). However, the differences between treatments were not significant for either character (Table 4), but significant differences were observed between periods. Similar results were obtained by ABDERRAHIM (1966) for Fayoumi and Alexandria breeds and by ABOUL-SEOD *et al.* (1970), who observed a slight improvement in fertility and hatchability for restricted Fayoumi hens, which were not consistant for R. I. R. Pullets restricted in their feeding in the rearing period had better fertility than that of full-fed pullets, but there was no difference in hatchability (LEE *et al.* 1971b).

As a general conclusion, the results obtained justify making a food restriction for layers to 85% but not to 75%. It is believed that it acts as a mild stress which may result in greater activity, besides preventing the deposition of fat around the sex glands, thus stimulating greater production.

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RELATIONSHIP BETWEEN THE EVAPOTRANSPIRATION OF RICE AND THE EVAPORATION OF EVAPORIMETERS

Many studies have been made on rice in order to use USWB Class A pan evaporimeter evaporation as a measure of the evapotranspiration of rice (THONGTAWEE 1965, CHAUDHRY—PANDE 1966, VAMADEVAN—DASTANE 1968, NAKAGAWA 1969, DASTANE *et al.* 1966, RAY—PANDEY 1969, ANONYMOUS 1970, VAMADEVAN 1971, DE DATTA *et al.* 1973). Different sizes of pan were also used for the estimation of evapotranspiration (SHARMA—DASTANE 1966, 1969, VAMADEVAN 1971). Even though the evaporation pans used as a practical tool for predicting evapotranspiration in the rice field are promising, it should be mentioned that the coefficients derived for a specific region may not necessarily and automatically be applied to other areas (VAMADEVAN 1971). Further, the ratio of evapotranspiration to evaporation varies with the season, the kind of crop, the crop cover and the kind of pan used (CHRISTIANSEN—HARGREAVES 1970). In recent years the Can evaporimeter has been suggested as being more or less as reliable as the USWB Class A pan evaporimeter. However, a relationship between evapotranspiration and the evaporation of various evaporimeters will be of considerable use in recommending the particular type of evaporimeter to be used. Hence, in the present investigation a relationship was sought between the evapotranspiration of rice, and USWB Class A pan evaporation and Can evaporation under experimental conditions.

The experiment was conducted at the wetland farm of the Tamil Nadu Agricultural University, Coimbatore campus, India, during the years 1971 to 1973. 7 imbatore is situated at 11°N and 77°E at an altitude of 498 m above sea level. The average annual rainfall of 613.5 mm falls on 49.8 rainy days.

The following treatments were applied: (I) Water management treatments: I_1 — maintaining a water depth of 5 cm daily throughout the crop growth period; I_2 — maintaining 5 cm water daily throughout crop growth with a stoppage of water for five days only at the end of the tillering period; I_3 — maintaining saturation daily throughout the crop growth period; I_4 — maintaining a water depth of 5 cm daily for four days and afterwards a stoppage of water for four days; and I_5 — maintaining a water depth of 5 cm daily for eight days and afterwards a stoppage of water for eight days; (II) Varieties: V_1 — Kannaki (IR 8 × TKM 6) and V_2 — Bala

(N 22 × T/N/1); (III) Nitrogen levels: N_0 — 0 kg, N_1 — 60 kg, N_2 — 120 kg, N_3 — 180 kg and N_4 — 240 kg nitrogen per hectare. A common dose of 60 kg P_2O_5 and 60 kg K_2O per hectare was applied uniformly to all the plots.

The experiment was laid out in a split plot design with the water management treatment and the varieties allotted to the main plot and the nitrogen levels allotted to the sub plots and replicated three times. In all, two monsoon (wet season) and two summer (dry season) crops were taken. The crops were transplanted on 30.7.1971, 18.2.1972, 17.7.1972 and 5.2.1973.

In order to estimate the evapotranspiration and effective rainfall, the drum culture technique evolved by DASTANE *et al.* (1966) was used with a slight modification, the modification being the use of earthern pots instead of metallic drums. Earthern pots of 45 cm diameter and 45 cm in height were used. They were made leak proof by coating inside and outside with wax and black japan. The pots were buried in the soil to a depth of 35 cm leaving 10 cm above the soil surface. Daily measurements were made up to ten days before harvest, when the last irrigation was given.

One litre empty cans were converted as Can evaporimeters and fixed into each plot of the first replication as per the specifications of SHARMA—DASTANE (1969). The Can evaporimeter was fixed inside the crop canopy and as the crop grew the Can evaporimeter was raised to the canopy level. The readings were taken every day at 0830 hours Indian Standard Time. The observations were recorded from the second day after transplanting up to harvest in all the plots. The water was changed every week.

The USWB Class A pan evaporimeter installed at the agro-meteorological observatory situated about 1 km away from the experimental field was used for study in the present investigation.

The actual evapotranspiration values for five water management treatments and two varieties were divided by the USWB Class A pan evaporation and Can evaporation to obtain ratios eliminating the influence of meteorological factors. These ratios are presented in Table 1. The following conclusions can be drawn from the table.

(i) The ratios in the monsoon season were found to be higher than that of the summer season, indicating that the evaporation from the evaporimeters was lower during the monsoons.

(ii) The evapotranspiration by the crop is also less during the monsoon compared to the summer season. This is probably due to the rate of transpiration being controlled primarily by the energy supply and the low water vapour deficit, but it was also affected by the stomatal opening and the supply of water to the leaves, and the rate of evaporation is also diminished.

(iii.) As far as evaporation is concerned the Can evaporimeter gave less evaporation than the USWB Class A pan evaporimeter, as reflected in the ratios. This is probably due to the microclimate situation prevailing within the crop community, the Can evaporimeter being placed in the field at the level of the crop canopy by changing the position of the Can evaporimeter as the crop grows.

(iv) The ratio between evapotranspiration and pan evaporation was found to be fairly close to unity, indicating that the USWB Class A pan values could be used to estimate the evapotranspiration of rice (DASTANE *et al.* 1966, RAY—PANDEY 1969, ANONYMOUS 1970). The reason attributed to this unity value being that the evapotranspiration from the swamp rice crop would follow the same trend as that from a free water surface since the energy available for evapotranspiration would be the same (DASTANE *et al.* 1966). The evapotranspiration to evaporation ratio at the International Rice Research Institute, Philippines, during dry season was 1.6 and in the wet season was 1.29 (ANONYMOUS 1969). DE DATTA *et al.* (1973) reported that there was no seasonal difference and a ratio of 1.6 was obtained in both seasons. The sunken screened open pan evaporimeter (SHARMA—DASTANE 1966), the Can evaporimeter (SHARMA—DASTANE 1969) and the GGI 3000 pan evaporimeter (VAMADEVAN 1971) were found to give a ratio near unity. In the present investigation different ratios for different water management

Table 1

Ratio between actual evaporationsiration and USWB class A pan evaporation and Can evaporation for different seasons, varieties and water management treatments

Water management treatments	Evapotranspiration/Can evaporation					
	Kannaki (V_1)			Bala (V_2)		
	Monsoon	Summer	Mean	Monsoon	Summer	Mean
I_1	1.45	1.60	1.53	1.43	1.53	1.48
I_2	1.44	1.51	1.48	1.39	1.45	1.42
I_3	1.26	1.27	1.28	1.22	1.20	1.21
I_4	1.48	1.44	1.46	1.46	1.40	1.43
I_5	1.52	1.45	1.49	1.45	1.32	1.39
Mean	1.43	1.45		1.39	1.38	

Water management treatments	Evapotranspiration/USWB Class A pan evaporation					
	Kannaki (V_1)			Bala (V_2)		
	Monsoon	Summer	Mean	Monsoon	Summer	Mean
I_1	1.46	1.27	1.37	1.40	1.25	1.33
I_2	1.40	1.21	1.31	1.38	1.19	1.29
I_3	1.24	1.04	1.14	1.20	1.03	1.12
I_4	1.43	1 20	1.32	1.40	1.16	1.28
I_5	1.39	1.20	1.30	1.38	1.15	1.27
Mean	1.38	1.18		1.35	1.16	

treatments and for different seasons were observed, but the differences were marginal. Ewart (1965) pointed out that great variations existed within the seasons.

(v) Maintaining the saturation throughout the crop growth period (I_3) gave the lowest ratio in all seasons and high ratios under submergence. According to Vamadevan (1971) a higher ratio was obtained for a water depth of 20 cm than for a water depth of 5 cm, evidently testifying that greater water depths always give a higher ratio, as reflected in the present study.

(vi) The differences between the varieties are minimal. Similar views have been expressed by Hargreaves (1968), who states that the type of crop seems to have little effect upon evapotranspiration.

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PHOSPHORUS AVAILABILITY FROM ROCK PHOSPHATE AS INFLUENCED BY PYRITES, WHEAT STRAW AND SUPERPHOSPHATE TO MAIZE-CLOVER ON A MOLLISOL

Nearly half the phosphate fertilizer requirement in India is presently met by imports. In view of the high price of fertilizers, particularly phosphates, on the international market and the unfavourable state of the balance of payments, the need to utilize inexpensive nutrient resources such as rock phosphate for improving soil fertility and increasing agricultural production can hardly be over-emphasized. The agronomic effectiveness of raw rock phosphates is often low as compared to soluble phosphatic fertilizers and is largely pH-dependent (ROGERS *et al.* 1953, PEASLEE *et al.* 1962). Consequently the use of raw rock phosphate is not recommended for neutral or alkaline soils. Since it is the latter group of soils which occupies most of the agricultural land in northern India, the present investigation was undertaken with a view to exploring the possibility of using raw rock phosphate in combination with low-grade pyrites, wheat straw or superphosphate as an alternative P source on these soils (Mollisol), which are relatively rich in organic matter. The need for this investigation primarily stemmed from the recent discovery of over 50 million tons of relatively poor quality rock phosphate and over 100 million tons of low-grade pyrites in India, which are not suitable for industrial use.

A greenhouse pot culture study was carried out on a typical tarai soil (Typic Hapludoll) collected from the University Farm. The relevant characteristics of the soil are given in Table 1. The composition of Mussoorie rock phosphate (90% — 100 mesh), superphosphate (powdery), low-grade pyrites (60% — 100 mesh) and what straw (finely ground) used in this study are given in Table 2. The treatments comprised three rates (20, 40 and 80 ppm P) or rock phosphate alone and in combination with 10 g per pot low-grade pyrites (1 + 5) or wheat straw; and superphosphate alone, as well as in the form of a mixture with rock phosphate (1 + 1), giving 10, 20 and 40 ppm P/pot. With the inclusion of some additional treatments, there were in all 22 treatments and four replications in a completely randomised design. Each pot contained 3 kg soil passed through a 2 mm sieve. After thoroughly mixing the requisite quantity of fertilizer and pyrites or wheat straw with the soil, the moisture was maintained at about two-thirds of the field capacity for 30 days in the greenhouse (temperature 25—29°C). Thereafter the soil was tested for pH and available P, and hybrid maize *(Zea mays)* var. "Ganga-2" was seeded and grown for 7 weeks. Each pot had five maize plants and received adequate N, K, S and micronutrients. After harvesting the maize plants, Egyptian clover *(Trifolium alexandrinum)* var. "Russian Giant" was seeded without fresh P application. Three clippings of clover were taken. Plant samples were washed, dried, weighed, ground and analysed for P by the molybdo-vanadate yellow spectrophotometric procedure after wet ashing with HNO_3—$HClO_4$ (Jackson 1958). Calcium was determined using a flame photometer in an aliquot of the plant material. Soil-pH was measured in a 1 : 2.5 soil-water suspension using a glass electrode pH meter, and available P was determined by extraction with 0.5 *M* $NaHCO_3$ (Olsen *et al.* 1954).

The P availability index was calculated by subtracting the P uptake in the check treatment from the P uptake in the fertilizer treatment and dividing the value by the amount of P added, multiplied by 100.

The data presented in Table 3 show that the height of maize plants was not significantly affected by the source or level of P application. It is evident from the dry matter yield data that raw rock phosphate virtually failed to stimulate the growth of maize plants, whereas superphosphate increased the yield significantly over the check treatment. P uptake by plants also exhibited the same trend. This supports the general view about the indispensability of a water-soluble P source for early plant growth response on neutral or alkaline soils (Rogers *et al.* 1953, Ensminger *et al.* 1967). The use of low grade pyrites mixed with rock phosphate seemed to have a beneficial effect as it tended to improve the effectiveness of the latter in terms of dry matter yield response which was statistically on a par with that of superphosphate at 30 and 40 ppm P levels. The increased uptake of P by maize plants receiving a mixture of rock phosphate and pyrites compared with those receiving rock phosphate alone (Table 3) indicates that the pyrites was able to mobilise P from rock phosphate by promoting its dissolution due to the local acidifying effect (Rastogi *et al.* 1977). However when compared at the same P level, the P availability index values for the rock phosphate-pyrites mixture were only one-fourth to one-half of the superphosphate values. A heavy dose of pyrites (10 + 1) did not substantially enhance the effectiveness of rock phosphate compared to the lower dose (5 + 1). Although the amount of pyrites added with rock phosphate was greater than what is theoretically required to convert all the carbonate/fluoro-apatite present in the rock phosphate into monocalcium phosphate, the relatively low effectiveness of this mixture compared to superphosphate may be attributed chiefly to poor contact between the acid produced from pyrites particles and

Table 1

Characteristics of the soil used

Particulars	Test value
Texture	Loam
ph (1 : 2.5 soil-water suspension)	7.5
Organic matter	1.46%
Cation Exchange Capacity	31.50 me/100 g
Exchangeable Ca	21.38 me/100 g
Exchangeable Mg	8.57 mg/100 g
Exchangeable K	0.51 me/100 g
Total	820 ppm
Water-soluble P	0.5 ppm
0.5 *M* $NaHCO_3$-extractable P	21.2 ppm
P fixation capacity	80 ppm

Table 2

Composition of rock phosphate, superphosphate, pyrites and wheat straw used in the experiment

Constituent	Rock phosphate	Super-phosphate	Pyrites	Wheat straw
Total P as P_2O_5 (%)	16.64	16.78	—	0.21
Water soluble P (%)	Traces	16.10	—	—
Citrate soluble P (% of total P)	10.80	1.36	—	—
Calcium as CaO (%)	47.20	26.80	0.80	0.20
Sulphur	Traces	13.40*	11.20$^+$	0.10
Organic carbon	Traces	—	Traces	44.73
Nitrogen	—	—	—	0.79
Fluorine	2.20	1.13	—	—
Iron as Fe_2O_3	5.64	1.28	12.80	—
Silica	4.88	1.56	42.50	3.89

* Mostly as SO_4''; $^+$ mostly as S''

rock phosphate particles. The incomplete oxidation of pyrites and the exhaustion of the acid so produced in other side reactions may also be responsible for the low efficacy of the pyrites.

Wheat straw had no discernible effect on the growth and dry matter yield of maize or on the P uptake by plants, probably because of its slow decomposition rate, the non-persistence of organic acids for longer periods under tropical conditions and the high Ca saturation of the soil. This observation is in line with those of SEATZ *et al.* (1959).

At the 10 ppm P level the mixture of rock phosphate and superphosphate produced less dry matter yield than did superphosphate but it appeared to be equally effective at

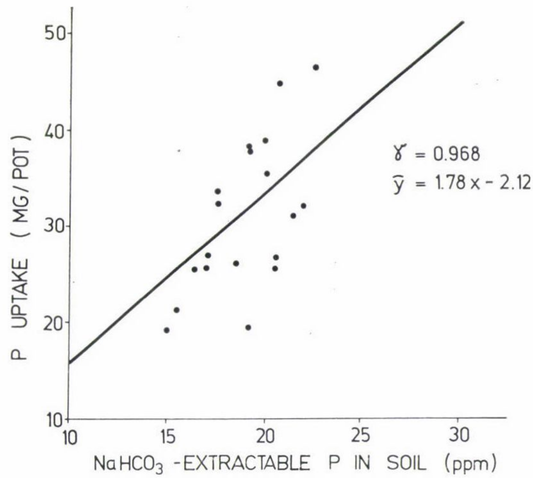

Fig. 1. Relationship between $NaHCO_3$-extractable P in soil and P uptake by maize plants

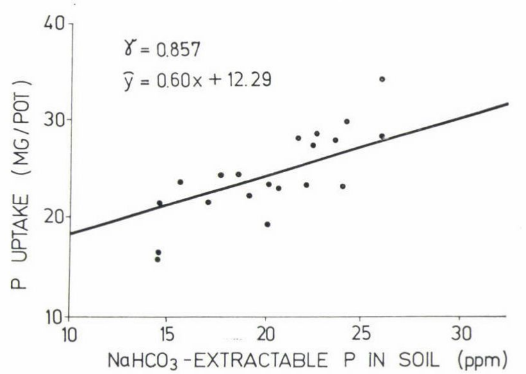

Fig. 2. Relationship between $NaHCO_3$-extractable P in soil and P uptake by clover

higher rates. There was no significant difference in P uptake at any P level between the plants receiving the rock phosphate-superphosphate mixture and those receiving superphosphate alone. An increase in the proportion of superphosphate in the mixture (2 + 1) resulted in better growth of maize plants and higher P uptake and utilization of added P, which compared fairly well with superphosphate at the corresponding P levels.

There was a close relationship between the P extractable in 0.5 *M* $NaHCO_3$ in soil determined after 30 days of incubation and the P uptake by maize plants ($r = 0.968$, significant at the 1% level), suggesting that the availability of rock phosphate can be predicted well by this laboratory test. Fig. 1 depicts this relationship for maize plants.

Residual effects. A marked response of clover plants to rock phosphate was observed and the differences between the P sources, namely superphosphate, rock phosphate alone and in combination with pyrites or wheat straw, levelled off at the 20 ppm P level, but there was no further increase in dry matter yield at higher levels of rock phosphate. The same trend was noticed in regard to P uptake. This limited availability of rock phosphate to clover in constrast to its ineffectiveness for the preceding maize could be explained by the better physio-

Table 3

Effect of sources and levels of P application on the growth and yield of maize and P uptake by plants

Treatment	P applied, ppm	Plant height, cm	Dry matter yield, g/pot	P uptake, mg/pot	P availability index
Check	0	77.8	34.76	21.29	—
Superphosphate	10	89.2	40.43	33.29	40.0
Superphosphate	20	85.1	44.96	38.95	28.3
Superphosphate	40	86.0	43.30	44.74	19.5
Rock phosphate	20	85.2	35.83	19.21	—3.5
Rock phosphate	40	85.7	35.60	25.62	3.6
Rock phosphate	80	84.9	39.40	26.04	1.9
Rock phosphate + Pyrites	20	90.0	35.96	25.55	7.1
Rock phosphate + Pyrites	40	91.8	38.50	32.39	9.2
Rock phosphate + Pyrites	80	88.1	40.36	38.08	7.0
Rock phosphate + Pyrites (1 + 10)	20	83.6	40.66	27.15	4.7
Pyrites alone 10 g	0	83.3	36.90	21.29	—
Rock phosphate + wheat straw	20	76.3	29.20	19.51	—2.9
Rock phosphate + wheat straw	40	83.7	37.80	25.22	3.3
Rock phosphate + wheat straw	80	40.9	37.10	31.25	4.1
Rock phosphate + pyrites (1 + 5) + wheat + straw	40	86.3	40.16	33.74	10.4
Wheat straw alone	0	82.0	33.66	18.28	—
Rock phosphate + super-phosphate (1 + 1)	10	79.8	32.73	26.70	18.0
Rock phosphate + super-phosphate (1 + 1)	20	81.6	38.23	32.13	18.0
Rock phosphate + super-phosphate	40	89.7	45.56	46.60	21.1
Rock phosphate + super-phosphate (1 + 2)	20	84.3	45.73	35.54	23.8
Rock phosphate + super-phosphate (1 + 1)	20	82.2	39.16	33.49	20.3
SEm ± C. D. at 5%		3.94 N. S.	2.12 6.06	2.58 7.35	— —

logical ability of the roots of the former as compared to the latter for utilizing insoluble calcium phosphates (Rogers *et al.* 1953).

The beneficial effect of pyrites on the availability of rock phosphate as observed with maize did not show up on clover, probably because the oxidation of pyrites in the soil had nearly ceased (as indicated by pH) and the resultant acid was already exhausted. On the other hand, the residual effects of the rock phosphate + wheat straw treatment were significantly better than those of rock phosphate alone. The availability of additional P to plants through the mineralisation of straw, as evident from a comparison of the P uptake value for the control as compared to wheat straw alone (Table 4), rules out the possibility of a substantial mobilisation of P from rock phosphate by straw, as also reported by Seatz *et al.* (1959).

The residual effectiveness of the rock phosphate-superphosphate mixture (1 + 1) appeared to be similar or superior to that of superphosphate except at the 40 ppm P level where the latter showed an edge over the former in regard to dry matter yield as well as P

Table 4

Residual effect of sources and levels of P application on the yield of clover and uptake of P and Ca

Treatment	P applied, (ppm)	Fresh yield, g/pot	Dry matter yield, g/pot	P uptake, mg/pot	P availability index	Ca uptake, mg/pot
Check	0	49.42	8.43	15.83	—	163
Superphosphate	10	55.69	8.72	19.24	11.4	189
Superphosphate	20	66.29	11.22	23.24	23.5	253
Superphosphate	40	84.73	15.32	34.42	15.5	362
Rock phosphate	20	73.23	13.69	23.72	13.1	273
Rock phosphate	40	70.83	12.22	22.32	5.4	269
Rock phosphate	80	72.85	12.92	24.28	3.5	291
Rock phosphate + pyrites	20	73.19	12.86	21.70	9.8	196
Rock phosphate + pyrites (1+5)	40	74.72	13.72	24.23	7.0	224
Rock phosphate + pyrites	80	73.13	12.52	23.42	3.2	219
Rock phosphate + pyrites (1+10)	20	67.86	10.93	22.37	10.9	191
Pyrites 10 g	0	58.59	9.86	16.64	—	171
Rock phosphate + wheat straw	20	87.22	14.52	28.40	20.9	248
Rock phosphate + wheat straw	40	79.52	14.02	28.60	10.6	256
Rock phosphate + wheat straw	80	78.13	13.22	29.92	5.9	261
Rock phosphate + pyrites (1+5) + + wheat straw	40	68.23	12.15	22.90	5.9	221
Wheat straw alone	0	68.86	11.42	21.45	—	210
Rock phosphate + superphosphate	10	69.59	11.72	23.51	25.6	235
Rock phosphate + superphosphate (1+1)	20	74.60	12.25	27.96	20.2	257
Rock phosphate + superphosphate	40	74.76	12.89	28.54	10.6	285
Rock phosphate + superphosphate (1+2)	20	67.13	12.29	24.63	14.7	249
Rock phosphate + superphosphate (2+1)	20	62.42	10.69	22.99	11.9	259
SEm ± C. D. 5%		4.52 12.88	0.79 2.25	1.84 4.28		17 48

Table 5

Cumulative P availability index of rock phosphate as effected by pyrites and wheat straw; rock phosphate-superphosphate mixture and superphosphate in greenhouse test with maize-clover

P source/treatment	P levels (mg/pot)			
	30	60	120	240
Rock phosphate		9.6	9.0	5.4
Rock phosphate + Pyrites		16.9	16.2	10.2
Rock phosphate + Wheat straw		15.6*	12.9*	9.6*
Rock phosphate + Superphosphate	43.6	38.2	31.7	—
Superphosphate	51.4	51.8	35.0	

* After accounting for P in straw added

uptake. These results are in good agreement with those of Terman *et al.* (1961) who reported that the effect of water solubility of fertilizer P was less pronounced for the second crop.

The uptake of P and Ca by clover plants was closely interrelated (r = 0.83).

The level of P extractable in 0.5 *M* $NaHCO_3$ in the soil, measured after harvesting the maize plants, showed a very close relationship with the P uptake by subsequent clover plants (Fig. 2). This indicates that the residual value of rock phosphate or superphosphate application can be conveniently evaluated by this laboratory test, as also reported by Moschler *et al.* (1957) and Beaton—Nielsen (1959).

Considering the cumulative P availability to both crops in the greenhouse (Table 5), one would conclude that the application of low grade pyrites or wheat straw could bring about only a marginal improvement in the efficacy of rock phosphate. A mixture of rock phosphate and superphosphate however offered a viable alternative for making use of inexpensive rock phosphate. These results must, however, be interpreted with caution keeping in view the soil—plant relationship obtained in the greenhouse, which would be very different under actual field conditions and may go in favour of rock phosphate, as pointed out by Terman *et al.* (1962).

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CHEMICAL CHANGES ACCOMPANYING WATER-LOGGING. I. EFFECT OF SULPHATE AND ORGANIC MATTER

The area of alkali soils in Egypt has been expanding since the introduction of the perennial irrigation system, which has caused a rise in the water table. RIZK (1958) and GRACIE *et al.* (1961) indicated that sulphate reduction is the process mainly responsible for soil deterioration, gleying, the development of black alkali soils and the formation of natron deposits in Wadi El-Natrun. SANDU (1962) attributed the formation of $NaHCO_3$ and Na_2CO_3 to the sulphate reduction process under water-logged conditions. HORDEN—WHITTING (1965) found that the rate of increase in exchangeable Na^+ was greatly increased by Na_2SO_4 in the presence of organic matter. The present study deals with the manifestation of the reduction processes and the development of alkalinity as a result of the water-logging of soil samples representing alluvial, sandy and calcareous soils in Egypt.

Three soil samples were used in this study: a clay loam alluvial soil from Sakha in Kafr El-Sheikh governorate, a highly calcareous soil from Mariout, and a sandy soil from Abo-Kaber in Sharkiya Governorate. Some chemical and physical properties of the investigated soils are shown in Table 1.

Table 1

Some physical and chemical properties of the investigated soils

Soil	pH 1/2.5	Air-dry soil %					Mechanical fractions %			C. E. C. Meq/100 g
		T. S. S.	S. P.	O. M.	Fe_2O_3	$CaCO_3$	clay	silt	sand	
Clay-loam	8.20	0.24	69	1.03	1.07	2.15	55.4	28.0	16.6	44.8
Calcareous	7.90	0.23	39	0.86	0.72	40.0	31.4	3.0	65.6	16.3
Sandy	8.10	0.05	19	0.17	0.52	0.82	11.4	4.0	84.6	9.6

Each soil received three treatments, namely 0.5% K_2SO_4, 0.5% K_2SO_4 + 2% organic matter in the form of potato starch, and a control treatment receiving no amendments. 150 g of each soil, passed through a 1.25 mm sieve, was mixed with 150 ml of CO_2-free distilled water in a wide-mouthed bottle. The bottles were stoppered and kept at room temperature in a wooden cabinet. Two replicates from each treatment were analysed at intervals of 12 hrs and 15, 45, 90 and 135 days. The pH and the oxidation-reduction potential were measured in soil suspension using a glass electrode and a platinum electrode separately, in connection with a KCl-saturated calomel electrode in a Beckman pH meter. The Eh readings were standardized to pH 7.0 (Eh 7). The soils suspension was filtered through a Buchner funnel and 150 ml of the filtrate were collected using CO_2-free distilled water. The soil remaining in the funnel was air-dried and analysed for exchangeable Na and K according to PIPER (1950). The extract was analysed for CO_3 and HCO_3 by titration with 0.02 N $KHSO_4$, for sulphate gravimetrically by precipitation with $BaCl_2$ after the removal of sulphide, for sulphide iodometrically (TREADWELL—HALL 1945), and for Ca and Mg by versenate.

A third replicate of each treatment in the alluvial soil was used for counting the most probable number of sulphate reducers according to ABD-EL-MALEK—RIZK (1958) and for a total microbial count using the standard plate count method of ALLEN (1949).

A. Effect of water-logging on chemical and microbiological changes in soil receiving no organic matter. Table 2 illustrates the changes in water-logged soils receiving no sulphate and organic matter. The oxidation-reduction potential of the calcareous soil showed a sharp decrease (from +444 to +71 Mv) during the first two weeks of water-logging and showed slight changes throughout. In sandy soil, the Eh_7 showed a gradual decrease all through the observation period (from +368 to +118 Mv). As for the clay-loam soil, the Eh_7 level remained almost stable during the first two weeks, followed by a gradual decrease until the end of the experimental period (from +376 to +166 Mv).

The pH of the clay-loam soil decreased slowly throughout the experimental period, reaching 6.95 after 135 days, while the sandy soil showed a small decrease during the first two weeks and then slowly rose again, reaching the initial pH by the end of the experiment (pH 7.7). The calcareous soil showed a similar trend. The drop in pH value is known to be due to organic acids released during the fermentation processes of organic matter under such water-logged anaerobic conditions. A change in the sulphate content of the soils was noticeable only in the calcareous soil. It decreased by 53% during the 4.5 months. However, $SO_4^=$ generally decreased slightly in the other two soils. In all the soils, $CO_3^=$ and HCO_3^- tended to increase during the 15—45 day period, followed by a small decrease thereafter. This may be due to water-logging, which disturbs the microbial equilibrium in favour of sulphate-reducers after 15 days. Soluble sulphides decreased from 0.33 to 0.03 meq/100 g in both alluvial and sandy soils within 4.5 months of water-logging and exhibited almost the same pattern throughout the experiments, indicating their precipitation as insoluble sulphides (mainly FeS). The soluble sulphides in the calcareous soil were few and fluctuating. The relatively large amount of sulphate reduced and the comparatively small amount of soluble sulphide remaining in solution

Table 2

Chemical changes accompanying water-logging in alluvial, sandy and calcareous soils

Soil	Time in days	pH	Eh_7 Mv	Meq/100 g air-dry soil					
				Soluble		Anions		Soluble cations	
				$CO_3^=$	HCO^-	$SO_4^=$	$S^=$	Ca^{++}	Mg^{++}
Clay-loam	0.5	7.92	+376	—	0.67	1.27	0.33	0.52	0.29
	15	7.45	+369	Tr.	1.38	1.20	0.33	0.52	0.34
	45	7.25	+292	Tr.	0.91	1.10	0.01	0.43	0.30
	90	7.05	+261	Tr.	0.76	1.20	0.01	0.40	0.29
	135	6.95	+166	—	0.69	1.08	0.03	0.40	0.27
Sandy	0.5	7.70	+368	—	0.42	0.15	0.33	0.39	0.16
	15	7.37	+299	—	0.67	0.05	0.33	0.37	0.17
	45	7.40	+185	—	0.75	0.02	0.00	0.45	0.19
	90	7.50	+161	Tr.	0.76	0.13	0.01	0.43	2.20
	135	7.70	+118	—	0.57	0.03	0.03	0.35	0.22
Calcareous	0.5	7.75	+444	—	0.50	2.57	0.04	1.67	0.49
	15	7.20	+71	—	0.84	2.20	0.07	2.02	0.90
	45	7.15	+ 23	Tr.	0.92	2.07	0.03	1.43	0.79
	90	7.30	+ 33	—	0.84	1.62	0.12	0.93	0.59
	135	7.30	+127	—	0.67	1.20	0.08	0.67	0.76

Table 3

Chemical changes accompanying water-logging in alluvial, sandy and calcareous soils which had received 0.5% K_2SO_4

Soil	Time in days	pH	Eh_7 Mv	Meq/100 g Air-dry soil					
				Soluble		Anions		Soluble cations	
				$CO_3^=$	HCO_3^-	$SO_4^=$	$S^=$	Ca^{++}	Mg^{++}
Clay-loam	0.5	7.50	+376	—	0.50	6.49	—	2.21	1.39
	15	7.32	+349	Tr.	1.01	6.51	0.16	2.21	1.60
	45	7.15	+282	Tr.	0.69	5.73	0.01	2.13	1.30
	90	7.00	+240	Tr.	0.57	5.75	0.01	1.85	1.46
	135	7.00	+161	—	0.50	6.13	0.01	1.90	1.67
Sandy	0.5	7.67	+382	—	0.59	5.68	—	1.60	0.73
	15	7.20	+399	—	0.54	5.53	0.33	1.64	0.90
	45	7.10	+248	—	0.57	5.50	0.01	1.95	1.15
	90	7.05	+138	Tr.	0.69	5.64	0.01	2.00	1.24
	135	7.40	+199	—	0.57	5.20	0.03	1.80	1.25
Calcareous	0.5	7.70	+415	—	0.50	7.77	0.06	2.80	1.10
	15	7.15	−11	—	0.92	7.58	0.05	2.73	2.02
	45	7.05	−8	Tr.	1.17	7.75	0.06	2.94	1.89
	90	7.20	+1	—	0.76	7.52	0.12	2.94	1.83
	135	7.20	+119	—	0.50	7.45	0.02	2.47	1.98

suggest its precipitation mainly as FeS. The soluble Ca and Mg in the clay-loam and sandy soils remained nearly constant all through the observation period. But in the calcareous soil, the figures of both cations showed a small increase within the first 2 weeks, followed by a gradual decrease throughout.

B. The effect of added sulphate. Table 3 shows the effects of water-logging in soils receiving 0.5% K_2SO_4. The chemical changes were very similar when 0.5% K_2SO_4 was added to the water-logged soils. The slightly lower values for pH, carbonates and bicarbonates were probably due to the weakly acidic K_2SO_4. The slightly higher values for soluble Ca and Mg were due to the exchange of K for these cations. A comparison of Table 2 and Table 3 indicates that the addition of soluble sulphate without organic matter did not result in any significant reduction features in water-logged soil.

C. Effect of organic matter on chemical changes in water-logged soils. Table 4 shows the chemical changes taking place in clay-loam alluvial, sandy and calcareous soils when water-logged for 4.5 months at room temperature. All the soils received 0.5% K_2SO_4 and 2% organic matter in the form of starch.

The table shows that the Eh_7 of the alluvial soil was drastically decreased from +360 Mv after twelve hours of water-logging to −265 Mv at the end of two weeks. This was followed by a noticeable increase in the Eh_7 during the month that followed, then a slow increase reaching +31 Mv by the end of the experiment. The large drop in Eh_7 during the first two weeks is

Table 4

Chemical changes accompanying water-logging in alluvial sandy and calcareous soils which had received $0.5\%\ K_2SO_4 + 2\%$ starch

Soil	Time in days	pH	Eh_7 Mv	Meq/100 g Air-dry soil					
				Soluble		Anions		Soluble cations	
				$CO_3^=$	HCO_3^-	$SO_4^=$	$S^=$	Ca^{++}	Mg^{++}
Clay-loam	0.5	7.30	+360	—	1.76	6.54	0.33	2.85	1.81
	15	6.05	−265	Tr.	3.85	6.05	0.67	4.41	5.18
	45	5.85	−57	—	3.52	3.82	0.04	3.80	4.11
	90	6.00	−46	0.25	4.78	1.06	0.09	1.95	2.03
	135	6.75	+31	Tr.	2.52	0.06	0.05	0.45	0.55
Sandy	0.5	7.10	+345	Tr.	0.84	5.87	0.33	2.03	0.83
	15	5.80	+91	—	2.85	5.31	0.50	4.06	2.72
	45	5.75	−65	—	2.51	3.95	0.11	3.60	2.54
	90	6.15	−74	0.38	3.08	1.48	0.14	2.35	0.84
	135	7.20	−57	0.44	1.95	0.10	0.15	0.78	0.80
Calcareous	0.5	7.30	+4	—	0.92	7.84	0.08	3.07	1.44
	15	6.10	−125	—	4.36	6.02	0.14	6.33	4.19
	45	6.30	−28	Tr.	4.70	2.68	0.17	3.40	3.33
	90	7.35	−43	Tr.	2.52	0.19	0.15	0.43	0.61
	135	7.60	+55	Tr.	2.10	0.29	0.07	0.23	0.37

believed to be due to the activity of the aerobes consuming atmospheric oxygen to oxidize the organic matter. The higher counts of aerobes in the alluvial soil compared with the sandy soil explain the much higher drop in Eh_7 in the clay-loam soil in the first two weeks. Table 4 shows that the change in the Eh_7 of the two soils during the 4.5 month period exhibits a very similar pattern. In this respect MUKHOPADHYAY *et al.* (1967) obtained similar results. The present study shows that the microbial counts of aerobes reached a maximum in the first two weeks and decreased thereafter (Table 5).

The initial rapid drop in the Eh_7 of the alluvial and calcareous soils may be explained on the basis of YAMANE—SATO's (1968) work. They proved that such a drop in the Eh_7 is caused by H_2 gas, which is a decomposition product of the soluble sugar contained in air-dried soils, since the $H_2—H^+$ system has an Eh_7 of −420 Mv. The subsequent increase in Eh_7 is probably due to the reabsorption of the H_2 gas. In the present work, however, the sandy soil showed a much slower decrease in Eh_7, probably owing to much lower microbial activity. The pH of the alluvial and sandy soils largely decreased during the first 45 days, reaching a minimum of 5.85 and 5.75 respectively, but increased thereafter reaching 6.75 and 7.20 at the end of 4.5 months. The initial decrease in pH is due to the production of organic acids as a result of organic matter decomposition. This is evident since the pH drop taking place in soils treated with 2% starch (Table 4) was much greater than the control treatments (Table 2) and those receiving only 0.5% K_2SO_4 (Table 3). Similar results were obtained by MAHAPATRA (1968).

Table 5

The effect of K_2SO_4 and starch addition to waterlogged clay loam soil on a microbial count

Treatment	Time in days	Microbial count $\times 10^3$/g	
		Total	Sulphate reducers
Control	0.5	900	1
	15	1900	3
	45	2000	7
	90	1600	8
	135	2400	11
0.5% K_2SO_4	0.5	1400	2
	15	3800	3
	45	2600	2
	90	1800	2
	135	2700	6
2% Starch + 0.5% K_2SO_4	0.5	1100	3
	15	4100	49
	45	2800	85
	90	2500	1045
	135	1200	232

Table 6

Effect on the exchangeable cations of water-logging of clay-loam soil receiving 0.5% K_2SO_4 and 2% starch

Time in days	Control			0.5% K_2SO_4			0.5% K_3SO_4 + 2% Starch.		
	Na	K	Ca+Mg	Na	K	Ca+Mg	Na	K	Ca+Mg
0.5	5.38	2.75	36.67	4.19	7.50	33.11	3.25	6.75	34.80
15	5.10	2.88	36.82	4.03	7.25	33.52	3.56	7.25	33.99
45	6.06	2.75	35.99	4.91	7.25	33.64	3.94	7.25	33.61
90	6.06	2.88	35.87	5.00	7.75	32.05	4.25	7.50	33.05
135	6.25	2.75	35.80	4.72	7.38	32.70	6.06	7.50	31.24

The increase of pH in the latter stage of water-logging may be partially due to the consumption of the organic acids by the sulphate reducers as electron donors to reduce the sulphates which act as sources of energy. The pH changes in the calcareous soil present a similar pattern to that of alluvial and sandy soils except that the lowest value was reached earlier, i.e. after 15 days. This is expected, since the Eh_7 drop and the maximum bicarbonate production and sulphate reduction (Table 4) took place faster than in the other two soils.

Carbonate and bicarbonate increased as the time of water-logging progressed, reaching a maximum after 3 months in alluvial and sandy soils (5.03 and 3.46 meq/100 g soil respectively), and decreased thereafter. In the calcareous soil the maximum accumulation of bicarbonate took place after 15—45 days and again decreased thereafter. The increase in carbonate and bicarbonate is probably paralleled by the increase in sulphate-reducers, which was indicated by the development of an intense black colouration of ferrous sulphide. Table 5 shows that the count of sulphate-reducers progressively increased, reaching a maximum after 90 days of water-logging in the alluvial soil. In this respect, Abd-El-Malek—Rizk (1963) found that the titratable alkalinity as a result of sulphate reduction in a synthetic medium is equivalent to the amount of sulphate reduced, regardless of the strain variation and energy source. Similar results were reported by Ogata—Bower (1965). The subsequent decrease is believed to be due to the precipitation of the carbonates of Ca and Mg. This is evident from Table 4, which shows the increase of both soluble Ca and Mg with the time of water-logging, due to the decrease in pH and the solubilization of the carbonates of such divalent cations. Corresponding to the maximum accumulation of $CO_3^= + HCO_3^-$, both Ca and Mg sharply dropped and continued to decrease to well below the initial values. It should be mentioned here that such a decrease is not mainly a pH effect, since the final pH values were comparable with the initial values and even lower in the alluvial soil. However, the final concentrations of Ca and Mg in all three soils were very much lower than the initial values.

A small reduction in sulphate was observed during the first two weeks of water-logging followed by strong reduction towards the end of the experimental period (Table 4). It is interesting to note that sulphate reducing seems to be faster in the calcareous soil than in either clay-loam or sandy soils. For instance, 70% of the sulphate present was found to disappear in calcareous soil after 1.5 months, compared to 42% and 32% for clay-loam and sandy soils respectively in the same period. This was true despite the fact that the calcareous soil contained higher amounts of initial sulphate. At the end of the experimental period, i.e. after 4.5 months, 97.6 to 99.1% of the sulphate in all the soils was found to disappear.

A comparison between Tables 3 and 4 shows that very little or no sulphate is reduced in soils receiving no organic matter and in which the Eh_7 remained relatively high, while almost all the sulphate was reduced in soils receiving organic matter in a period of 4.5 months of water-logging. The amount of soluble sulphide found in all the soil during the experiment was practically negligible if compared with the amount of $SO_4^=$ reduced. The amount of easily reduced iron was found to be 13.40, 9.0 and 6.5 meq/100 in alluvial, calcareous and sandy soils respectively, while the amount of sulphate was 6.5, 7.8 and 5.7 meq/100 g in the respective soils after the addition of 0.5% K_2SO_4. This indicates that $S^=$ resulting from the reduction of sulphate was readily precipitated by the ferrous ions produced under such reducing conditions, giving rise to gley formation with very little soluble $S^=$ left in solution.

The exchangeable Na of alluvial soil increased slightly in the early stages of water-logging but largely increased at the end of the experiment, namely from 4.25 to 6.06 meq/100 g in the last 45 days of the experiment (Table 6). This large increase took place after the soluble Ca and Mg had decreased considerably due to precipitation as carbonates. The exchangeable K, however, slightly increased from 6.75 to 7.50 meq/100 g during the experimental period. The exchangeable Ca + Mg were calculated as the difference between the C. E. C. and the exchangeable Na + K. The increase in exchangeable Na and K was naturally accompanied by an equivalent decrease in exchangeable Ca + Mg. Similar results were obtained by Ogata—Bower (1965) and Janitzky (1967). The decrease in exchangeable Ca + Mg was more evident in the latter stages of the experiment, where they decreased from 33.05 to 31.24 meq/100 g soil in the last 1.5 months of the experiment.

The alkali Mg soils in San-el-Hagar and Shalma are believed to be formed by a similar mechanism, where $CaCO_3$ is precipitated first, thus increasing the relative concentration of

Mg and Na in solution. These two cations are adsorbed on the exchange sites occupying higher portions of the cation-exchange capacity. It can be stated that organic matter and the microbial activity of the aerobes, followed by the flourishing of the sulphate-reducers, are the main factors responsible for sulphate-reduction with its characteristic features, namely the decrease in the oxidation-reduction potential, the development of alkalinity, the decrease in the sulphate content and divalent soluble and exchangeable cations, and the increase in exchangeable monobasic cations.

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STUDIES ON THE UTILISATION OF PHOSPHORUS BY COTTON AT DIFFERENT STAGES OF GROWTH USING LABELLED SUPERPHOSPHATE

It has been reported earlier that the response of cotton to phosphate fertilisation is poor, depending on the mode of application (Sahni—Dhar 1964, Sinha 1970) and the response to nitrogen is variable (Singh 1967, Sinha *et al.* 1967). The present investigation was therefore intended to study the response of cotton to phosphate fertilisation under different modes of application using labelled superphosphate at different stages of growth with and without the combination of nitrogen and potassium in order to find out its maximum utilisation. The data on the growth and yield in this investigation was reported earlier (SINHA *et al.* 1967).

Cotton variety H-14 *(G. hirsutum)* was grown in 5.48 × 6.09 m plots at theAgronomy Division of this Institute during 1964 and 1965 to accommodate seven rows 75 cm apart having 20 plants in each row at a spacing of 20 cm. The rotation was cotton-oats, where 20 kg N per ha were applied to the oats each year. Labelled single superphosphate (33 kg P_2O_5 per ha) was applied in combination with two doses of nitrogen (56 and 112 kg N per ha) or 112 kg N + 56 kg K_2O per ha with three methods of placement (surface application, 7.62 cm and 12.70 cm below the surface in a single band) in a randomized block design containing five replications. Nitrogen and potash were applied broadcast. Nitrogen was also applied alone in two doses to study its effect separately.

Samples were collected at 3, 6, 9 and 12 weeks after sowing and analysed for total P colorimetrically by the vanadomolybdate method (KOENIG—JOHNSON 1942) and for radioactive P by the method of MACKENZIE—DEAN (1950).

The pH of the soil was 7.8 and contained 0.48% organic carbon and 196, 13 and 206 kg per ha available N, P_2O_5 and K_2O respectively.

Another field experiment was conducted in which carrier-free P^{32} was applied to the roots of cotton plants at different radii and depths in order to find out the maximum uptake of P^{32} by the roots. For this purpose, two varieties of cotton (H-14 and R_{231}) were grown in three replicates. 16μc of $P^3{}_9$ (carrier-free) was applied 3 weeks after sowing around the roots of each plant uniformly at a radius of 10 cm, 20 cm and 30 cm. The leaves were regularly harvested after every week and a uniform portion of the leaf was directly assayed for P^{32} activity.

Concentration of P in the cotton plants. The statistical analysis of data on the cotton plant for the two years (Table 1) reveals that the concentration of phosphorus as mg/g material at different stages of growth was not greatly affected by the different treatments, and in some cases the effect was not uniform. However, in most cases, the effect was not significant in either of the years. The mode of application (broadcast or placement) of the phosphorus did not affect the concentration of P in the plant. The phosphorus concentration as mg/g material was found to be higher after 3 weeks' growth than after 6 weeks' growth. It was also observed that the concentration of P in the stem was low as compared to that of the leaf or the floral parts of the plants. Nitrogen or potassium had no effect.

This study suggests that the cotton plant does not respond favourably to phosphatic fertiliser or its mode of application in its phosphorus composition, and the absorption of P from the soil is better at the initial growth stage of the plant.

Phosphorus derived from applied fertiliser. Phosphorus derived from the applied fertiliser was significantly affected by treatments at different stages of growth and in the different parts of the cotton plant in both the years (Table 2). Only when phosphate was applied was there a significantly favourable response, while nitrogen had no effect. The favourable response by placement of the phosphatic fertiliser either 7.62 cm or 12.70 cm below the soil surface was markedly higher than that of surface application at all stages of growth and in different plant parts (stem, leaf and floral) in both the years, thereby suggesting that the utilisation of phosphatic fertiliser when applied below the surface is more effective than when applied broadcast. This suggests that phosphorus, being immobile, is efficiently absorbed by placement near the root zone. The response due to placement was similar at different stages of growth except in the case of floral parts after 12 weeks' growth, where the percentage of phosphorus derived from the applied phosphorus was slightly lower, ranging from about 10 to 17%, in place of the normal 15 to 27%. It was also observed that increasing the nitrogen dose or the addition of potassium had no effect in increasing the efficiency of utilisation of applied phosphate.

Table 1

Effect of different treatments on the concentration of P in the cotton plant at different stages of growth for the years 1964 and 1965 (mg/g plant material-average of 5 replicates)

Treatments (a)	3 weeks		6 weeks		9 weeks		12 weeks				
							Stem		Leaf		Floral
	1964	1966	1964	1965	1964	1965	1964	1965	1964	1965	1965
C	3.66	2.67	2.48	2.52	2.87	1.95	1.66	0.98	3.68	1.91	4.00
N_1	3.63	3.02	2.52	2.27	2.49	2.00	1.69	0.99	3.27	1.98	4.29
N_2	3.74	3.28	2.66	2.50	2.84	2.03	1.90	0.92	3.91	1.82	4.27
N_1P_1	3.85	3.13	2.46	2.40	2.93	2.13	1.96	0.97	4.24	2.00	3.80
N_1P_2	3.75	3.00	2.70	2.47	2.83	1.97	2.08	0.93	3.72	2.15	4.01
N_1P_3	3.74	2.89	2.89	2.36	2.74	1.97	1.86	1.15	3.60	2.16	4.27
N_2P_1	3.74	2.51	2.51	2.48	2.78	1.86	1.94	0.98	3.76	1.95	3.96
N_2P_2	3.81	2.76	2.74	2.40	2.82	2.02	2.09	1.06	3.57	2.22	4.20
N_2P_3	3.58	3.07	2.44	2.38	2.57	2.03	2.04	1.03	3.64	1.97	4.01
N_2KP_1	3.54	2.84	2.46	2.43	2.87	1.96	1.90	1.02	3.91	1.96	4.34
N_2KP_2	3.76	2.87	2.76	2.32	2.86	1.83	1.96	1.12	3.76	2.09	4.30
N_2KP_3	3.70	3.30	2.80	2.37	2.85	1.92	2.12	1.00	3.59	2.06	4.33
Treatments											
SEM	0.092	0.156	0.101	0.134	0.138	0.093	0.084	0.066	0.220	0.080	0.169
C. D. (5%)	NS	0.433*	NS	NS	NS	NS	0.233**	NS	NS	0.221*	NS
Combination VS Rest											
SEM	0.038	0.064	0.041	0.055	0.056	0.038	0.034	0.027	0.090	0.033	0.069
C. D$_6$ (5%)	NS	NS	NS	NS	NS	NS	0.095**	NS	NS	0.090*	NS
N											
SEM	0.053	0.09	0.058	0.077	0.079	0.054	0.048	0.038	0.127	0.046	0.098
C. D. (5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
P											
SEM	0.065	0.111	0.071	0.095	0.097	0.066	0.059	0.047	0.155	0.056	0.120
C. D. (5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.156*	NS
NXP											
SEM	0.092	0.156	0.101	0.134	0.138	0.093	0.084	0.067	0.220	0.080	0.169
C. D. (5%)	NS	0.433*	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rest											
SEM	0.092	0.156	0.101	0.134	0.138	0.093	0.084	0.067	0.020	0.080	0.169
C. D. (5%)	NS	0.433*	NS	NS	NS	NS	0.233**	NS	NS	NS	NS

* 'F' test significant at the 5 % level
** 'F' test significant at the 1% level
NS Not significant

C Central
N_1 56 kg N/ha
N_2 112 kg N/ha
K 56 kg K_2O/ha

P_1 Broadcast
P_2 7.62 cm below surface
P_3 12.70 cm below surface
(phosphorus dose 33 kg P_2O_{58}ha)

Table 2

Effect of applied phosphorus on the fraction of total P in the cotton plant derived from fertilizer at different stages of growth for the year 1964 and 1965 (expressed as percentage-average of 5 replicates)

Treatments (a)	3 weeks		6 weeks		9 weeks		12 weeks				
							Stem		Leaf	Koral	Floral
	1964	1965	1964	1965	1964	1965	1964	1965	1964	1965	1965
N_1P_1	4.25	2.12	5.08	1.60	4.87	2.47	6.44	5.86	5.80	5.22	7.22
N_1P_2	16.62	19.55	15.47	18.55	15.24	17.45	16.39	18.06	16.50	18.71	14.96
N_1P_3	20.11	24.52	21.43	26.73	19.38	21.24	20.01	21.53	20.23	23.16	13.46
N_2P_1	4.94	2.54	5.94	1.72	5.54	3.72	6.36	6.52	6.56	5.74	6.62
N_2P_3	15.36	7.09	15.28	17.13	16.69	20.70	15.23	17.09	15.63	16.81	14.28
N_2P_3	19.55	24.60	21.09	26.83	21.36	26.01	17.65	21.44	17.91	22.73	17.05
N_2KP_1	4.91	2.23	5.17	19.4	5.42	2.44	7.31	8.00	6.78	7.17	5.94
N_2KP_2	14.63	15.48	15.04	16.60	15.88	18.87	16.38	20.84	16.38	20.13	17.61
N_2KP_3	18.63	23.57	18.30	23.27	17.98	22.12	14.85	15.61	14.72	16.09	10.03
Treatments											
SEM	1.468	3.289	1.483	2.708	1.217	2.237	1.025	2.331	1.141	2.532	1.420
C. D. (5%)	4.070**	9.116**	4.112**	7.506**	3.373**	6.478**	2.840**	6.460**	3.164**	7.019**	3.937**
Combination VS Rest											
SEM	0.599	1.343	0.606	1.101	0.497	0.954	0.418	0.951	0.466	1.0337	0.580
C. D. (5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N											
SEM	0.848	1.899	0.856	1.563	0.702	1.349	0.592	1.346	0.659	1.462	0.520
C. D. (5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
P											
SEM	1.038	2.326	1.049	1.915	0.860	1.652	0.725	1.648	0.807	1.791	1.004
C. D. (5%)	2.878**	6.446**	2.907**	5.308**	2.385**	4.580**	2.008**	4.568**	2.237**	4.963**	2.784**
NXP											
SEM	1.468	3.289	1.483	2.708	1.217	2.337	1.025	2.331	1.141	2.532	1.420
C. D. (5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
REST											
SEM	1.468	3.289	1.483	2.708	1.217	2.337	1.025	2.331	1.141	2.532	1.420
C. D. (5%)	4.070**	9.116**	4.112**	7.506**	3.373	6.478**	2.840**	6.460**	3.164**	7.019**	3.987**

** 'F' test significant at the 1% level
NS Not significant

(a) Treatments as indicated in Table 1

Table 3

Uptake of P^{32} (cpm) by the roots of the cotton plant during 1964 and 1965 (Average of 3 replicates)

P^{32} applied at different radii (R) and dephts (D) (a)	1st week		2nd week		3rd week		4th week		5th week		6th week	
	1964	1965	1964	1965	1964	1965	1964	1965	1964	1965	1964	1965
Variety H-14												
R_1D_1	1.153	2.083	2.820	4.243	4.496	6.677	3.180	4.123	2.760	4.253	1.470	2.036
R_1D_2	2.086	2.990	8.130	10.477	12.926	17.593	10.150	13.620	8.163	10.287	2.353	3.980
R_1D_3	1.330	1.690	2.606	4.026	5.370	9.063	4.130	7.000	3.326	5.613	1.483	1.666
R_2D_1	0.640	0.780	1.993	1.873	2.893	2.907	2.833	4.223	2.206	2.433	1.050	1.423
R_2D_2	1.096	1.530	2.680	2.687	4.656	7.200	4.853	7.663	3.576	5.920	1.623	2.227
R_2D_3	0.506	0.660	2.186	2.123	3.720	5.927	3.506	3.883	2.770	2.803	1.053	1.412
Variety R 231												
R_1D_1	0.980	1.396	2.153	2.230	3.270	2.470	1.123	1.040	1.347	2.017	1.013	1.727
R_1D_2	2.243	4.190	7.810	10.723	10.626	12.207	6.317	5.936	7.747	4.853	3.327	3.570
R_1D_3	1.400	3.630	2.136	6.380	4.236	8.580	3.457	4.330	2.853	3.716	1.913	2.130
R_2D_1	0.620	0.600	1.693	1.387	2.240	1.773	1.510	1.436	1.420	1.333	0.940	1.000
R_2D_2	0.930	0.869	3.713	4.174	2.780	2.693	2.423	2.266	1.873	1.730	1.483	1.530
R_2D_3	0.440	0.320	1.820	1.500	2.177	1.790	1.637	1.686	1.240	1.273	1.147	1.393
Treatments												
SEM	0.118	0.441	0.297	0.576	0.381	0.883	0.423	0.556	0.277	0.476	0.328	0.250
C. D. (5%)	0.346**	1.293**	0.873**	1.638**	1.119*	2.590**	1.240**	1.630**	0.811**	1.395**	0.962**	0.773**
Variety												
SEM	0.048	0.180	0.121	0.235	0.156	0.361	0.173	0.227	0.113	0.194	0.134	0.102
C. D. (5%)	NS	NS	NS	NS	0.457**	1.057**	0.506**	0.666**	0.331**	0.570**	BS	NS
Doses												
SEM	0.083	0.312	0.210	0.407	0.270	0.624	0.299	0.393	0.196	0.336	0.232	0.177
C. D. (5%)	0.245**	0.914**	0.617**	1.193**	0.791**	1.832*	0.877*	1.153**	0.574**	0.987**	0.680**	0.518**
VXD												
SEM	0.118	0.441	0.297	0.567	0.381	0.883	0.423	0.556	0.277	0.476	0.328	0.250
C. D. (5%)	NS	1.293**	NS	1.688*	NS	NS	1.240*	1.630**	0.811**	1.395**	NS	NS

(a) Radius: R_1 — 10 cm; R_2 — 20 cm

Depth: D_1 — 10 cm; D_2 — 20 cm; D_3 — 30 cm

* 'F' test significant at the 5% level

** 'F' test significant at the 1% level

NS Not signifcant

Uptake of P^{32} by roots. The uptake of P^{32} by the roots was significantly affected when the phosphorus was applied at different radii and depths during the growth of the cotton plant (Table 3). Significant varietal differences were observed between the 3 week and 5 week growth stages and the variety H-14 proved to have a better response. The uptake was maximum after 3 weeks' growth at a radius of 10 cm and a depth of 20 cm in both the varieties in both the years, thereby suggesting that the absorption by cotton roots is most efficient after placement near the root zone at this stage of growth.

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THE EFFECT OF B-NINE ON GROWTH OF DATURA METEL L.

In the literature certain trials dealing with the response of growth in plants belonging to the genus *Datura* to various growth regulators have been recorded (e. g. B-995, Alar, SADH). It should be recognized, however, that there is at present insufficient evidence bearing on the influence exerted in this respect due to B-9. The few publications available in this connection were even shown in most cases to deal with species other than *Datura metel.* In such studies, the effect of B-9 on growth generally appeared to be of an adverse nature (Sciuchetti—Born 1965 on *D. tatula*, Sciuchetti—Iturrian 1965 on *D. innoxia*).

The present work aimed at studying the effect of B-9 on certain aspects of growth in *D. metel.* As the manner of treating the plants with growth regulators could probably determine the nature of the response shown in this respect, the B-9 was supplied to the plants throughout this investigation by two methods. One of them depended upon soaking the seeds before sowing in the growth substance employed, whereas in the second, the same compound was added to the plants as a foliar spray.

This study was carried out on *Datura metel* in the 1970 season, then repeated in that of 1971, in the Farm of the Botany Laboratory, National Research Centre, Cairo.

The seeds were sown in seed-beds on March 23rd in both seasons. The seedlings were transplanted, one month after sowing, into clay pots (25.4 cm in diameter) containing fresh Nile silt and sand in the proportion of 3 : 1. The mixture of fertilizers was added in the form of 4 g ammonium sulphate, 5 g superphosphate and 2 g potassium sulphate per pot. In both seasons, there were four replicates for each of the concentrations (treatments) used. Every replicate was represented by 7 pots, each containing two more or less homogeneous plants at the start of experimentation. The replicates were arranged in a complete randomized block design.

B-9 (succinic acid-2,2-dimethyl-hydrazide) was applied in both seasons by one of the following methods:

1. Spraying: The seedlings were sprayed twice, the first spraying being 3 weeks after transplanting, whereas the second was one week later. Spraying was carried out using a small pressure pump. Just sufficient of the solution was sprayed to cover the plant foliage completely until it began to drip.

2. Soaking: the seeds were soaked for 12 hours before sowing in the growth regulator used.

For both types of application, four B-9 concentrations were employed: 0 (control), 250, 1000 and 4000 ppm (in distilled water).

The estimation of plant height (main stem) as well as counting the number of either branches or leaves (per plant) were carried out in both seasons at 7-day intervals, beginning from the 11th week after sowing in the case of either plant height or number of leaves, and from the 13th week after sowing in the case of the number of branches. In addition, three samples from each treatment were taken at about one month intervals. The first was harvested at late vegetative growth (about 84 days from planting), the second sampling took place during flower-bud opening (the fruit-set has not yet begun at that time), whereas the third sample was taken during fruit maturation (meanwhile, the sampling plants might still carry some flowers that had not yet set fruits). At the first sampling date (in both seasons), eight plants from four pots were used, whereas at both the second and third sampling dates, four plants from four different pots were taken. The roots were carefully cleaned from sand and silt particles. Each plant was separated into leaves, stems including lateral branches, and roots. The detached organs were oven-dried at 105°C for 24 hours, then the dry weight was determined.

The data presented in Tables 1, 2 and 3 indicate that both the increase in height and number of branches per plant generally appeared to be increased throughout ontogenesis due to spraying with the 250 ppm concentration of B-9, though the reverse proved to be true in the case of the 4000 ppm concentration, when applied in the same manner. As to the number of leaves per plant, however, the response shown to spraying with B-9 proved to depend, in part, upon plant age. Till about the 15th week from sowing, the differences noticed in this respect were statistically insignificant, whereas later, a stimulation was generally observed at both the 250 and 1000 ppm levels, particularly the former. On the other hand, when using B-9 in any concentration as a soaking medium, the above-mentioned growth criteria (i.e. increase in height, number of branches/plant and number of leaves/plant) were generally enhanced, though the superior concentration proved in each case to be a function of plant age. Thus, at the relatively early period (till about the 13th—15th weeks after sowing), the highest stimulation was shown at the 1000 ppm level, whereas later it occurred at the 250 ppm level.

Concerning the changes indicated in dry weight shown in Table 4, it might be preferable to compare the values obtained at the last sampling date only (i.e. at the fruit maturation stage). This would seem to be of more benefit in showing how the different treatments with the growth substance employed were able to affect the net accumulation of dry matter throughout the growth period. Such values (Tables 4 and 5) revealed that the application of B-9, either as a spray or as a soaking medium, tended in most cases to lower the dry weight of

Table 1

Average plant height of D. metel plants (cm/plant)

B-9 conc. (ppm)	Plant age 11 a	11 b	12 a	12 b	13 a	13 b	14 a	14 b
1970								
0	7.5	4.7	11.8	8.9	18.9	12.0	23.9	17.9
250	11.1	6.7	14.7	16.3	23.0	26.8	29.0	31.4
1000	10.0	8.2	13.6	18.0	18.7	29.2	23.1	30.1
4000	7.7	5.5	10.4	8.8	13.9	14.6	18.7	19.0
L. S. D. at 5% level	N. S.	1.4	1.8	2.6	3.1	8.9	2.9	3.1
1971								
0	16.6	10.6	25.4	19.5	29.6	24.5	32.6	30.1
250	17.6	18.2	26.6	28.4	29.5	29.6	33.6	36.8
1000	17.2	21.5	24.1	30.0	27.2	34.2	31.2	36.8
4000	16.6	15.7	23.9	22.6	25.6	29.4	30.9	32.0
L. S. D. at 5% level	N. S.	2.3	1.8	2.9	2.3	2.0	1.6	3.2

a = spraying; b = soaking

Table 2

Average number of branches per plant

B-9 conc. (ppm)	Plantage 13 a	13 b	14 a	14 b	15 a	15 b
1970						
0	2.5	1.3	3.3	2.0	4.8	2.3
250	3.1	0.0	3.2	2.0	7.0	4.0
1000	2.0	3.2	2.0	4.9	3.3	6.0
4000	2.0	2.0	2.0	4.7	2.7	5.7
L. S. D. at 5% level	N. S.	0.7	0.8	2.4	2.3	2.2
1971						
0	4.9	3.7	5.3	4.6	6.5	4.9
250	4.7	7.0	6.7	6.9	7.3	8.5
1000	4.4	7.2	5.0	7.3	6.4	9.4
4000	4.1	5.0	4.7	5.7	5.7	6.8
L. S. D. at 5% level	N. S.	0.8	0.6	1.7	N. S.	1.7

a = spraying; b = soaking

as affected by different B-9 treatments

(weeks from sowing)

15		16		17		18		19	
a	b	a	b	a	b	a	b	a	b
season									
26.8	26.1	28.1	29.1	29.6	30.0	30.2	37.7	33.55	39.5
38.2	36.0	41.6	38.5	47.6	42.1	56.6	48.1	61.6	49.4
27.8	33.7	30.8	34.0	32.9	35.2	37.4	39.7	40.6	41.5
24.5	27.3	27.1	31.0	27.7	33.4	29.6	38.5	31.0	40.6
6.1	3.7	5.3	6.7	7.2	7.1	5.6	N. S.	6.6	N. S.
season									
34.9	34.0	35.6	36.1	39.4	38.2	40.0	40.1	43.2	43.7
36.2	41.3	39.4	45.3	41.2	49.0	44.5	50.7	47.0	56.2
34.0	39.7	36.9	42.2	38.5	46.4	39.3	47.4	42.3	51.8
32.9	37.3	33.3	39.2	35.1	42.0	35.9	42.8	36.6	48.6
N. S.	3.5	N. S.	3.4	3.4	3.3	2.7	5.7	4.0	4.8

in D. metel as affected by different B-9 treatments

weeks from sowing)

16		17		18		19	
a	b	a	b	a	b	a	b
season							
6.6	4.9	7.0	5.7	7.7	7.6	9.8	10.7
8.0	8.6	14.0	10.3	21.5	10.3	22.7	12.0
5.3	7.1	8.4	7.7	13.3	9.8	14.0	11.2
4.3	6.2	6.7	6.7	7.0	8.6	8.3	10.7
2.0	2.0	2.7	2.7	7.1	2.7	4.3	N. S.
season							
8.0	5.9	9.7	6.4	11.5	9.9	12.6	10.3
8.5	14.4	10.1	15.9	12.6	24.5	15.7	24.8
7.2	10.0	8.1	11.7	9.6	15.3	11.3	16.1
6.3	8.8	7.5	10.7	9.1	13.3	9.3	14.4
1.4	2.6	0.9	1.7	2.1	5.7	1.0	5.0

Table 3

Average number of leaves per plant

B-9 conc. (ppm)	Plant age							
	11		12		13		14	
	a	b	a	b	a	b	a	b
1970								
0	5.3	5.7	8.0	7.2	11.1	8.3	13.9	9.0
250	5.6	5.9	10.4	8.8	11.7	11.1	14.2	12.0
1000	5.8	6.4	9.4	9.6	11.0	11.7	12.7	11.8
4000	5.0	5.7	7.8	6.7	10.0	8.9	11.0	10.0
L. S. D. at 5% level	N. S.	N. S.	N. S.	1.4	N. S.	1.5	N. S.	1.4
1971								
0	8.8	8.0	13.8	11.5	14.2	13.8	18.7	15.6
250	9.6	8.4	14.8	14.7	15.1	15.7	20.8	21.3
1000	9.3	9.7	13.0	15.4	13.7	15.9	19.7	19.0
4000	9.4	9.1	11.6	13.7	12.7	14.5	17.7	18.6
L. S. D. at 5% level	N. S.	1.0	N. S.	1.7	N. S.	N. S.	N. S.	2.7

a = spraying; b = soaking

leaves, stems and roots, as long as the 4000 ppm concentration was used, though the reverse proved to be true with regard to the other two levels, particularly the 250 ppm level.

Our results showed that B-9 in low concentrations could generally stimulate plant growth whether applied by spraying or soaking. However, at high levels, the same substance seemed to behave either as a stimulant or as a retardant, this being a function of the growth aspect concerned as well as the method of application.

That shoot growth could be enhanced by B-9 was reported in the literature, though infrequently (Hore—Bose 1968 on some *Hibiscus* spp. and *Malvaviscus conzattii*). In the same connection, Lavsen (1967) indicated that B-9 had no dwarfing effect on *Datura* plants.

On the other hand, the retarding ability of B-9 on height increase, observed in some of our treatments, is in accordance with the findings of many investigators (James—Sciuchetti 1964 on *Datura innoxia*, Sciuchetti—Born 1965 on *Datura tatula*, Mitlehner 1968 on *Chrysanthemum morifolium*, Jasa *et al.* 1971 on *Salvia splendens*, Kato 1972 on cucumber). The obtained suppression in plant height seems to have resulted from a decrease in internode length and/or the number of internodes. The reduction in internode length due to B-9 application was observed in certain studies, e.g. by Batjer *et al.* (1964) on apples, pears and sweet cherries and by Jaffe—Isenberg (1965) and Kato (1972) on cucumber. The internode initiation was also shown in the last investigation to be retarded under the same conditions. The inhibition in height increase, noticed in the present study, might further be regarded as the response of the auxin level in plant tissues to B-9 treatments. In this respect, Reed—Moore (1965), in experiments with peas, attributed the growth retarding effect of B-995 to the formation of 1,1-dimethylhydrazine in vivo: this hydrazine having a strong inhibiting action on tryptamine oxidation by epicotyl homogenate. Tryptamine is regarded as one of the possible *in D. metel as affected by different B-9 treatments*

(weeks from sowing)									
15		16		17		18		19	
a	b	a	b	a	b	a	b	a	b
season									
14.4	12.4	14.6	13.4	16.8	15.5	18.5	24.4	19.3	26.4
17.6	14.4	25.8	15.6	39.7	17.1	49.6	27.0	52.5	29.4
16.5	14.0	19.3	14.8	23.3	16.0	24.8	26.1	31.0	27.0
12.1	13.2	14.8	14.5	15.8	15.8	18.0	25.7	23.0	26.0
N. S.	N. S.	4.0	N. S.	5.5	N. S.	8.1	N. S.	7.7	N. S.
season									
22.5	18.4	22.6	20.0	24.3	23.5	24.9	24.7	27.8	29.5
24.8	29.1	25.8	32.2	30.2	42.6	32.5	51.7	34.3	60.2
22.0	21.4	22.8	23.9	26.4	29.2	28.2	31.7	33.0	39.4
21.9	21.4	22.4	22.9	23.3	26.3	24.1	27.6	26.7	32.2
N. S.	5.2	2.6	4.8	5.3	6.1	3.4	7.0	N. S.	4.5

intermediates in auxin formation. It might be thought that a similar retarding action of B-9 on auxin formation (through the inhibited oxidation of tryptamine to indoleacetaldehyde) might have occurred in our treated plants, but only at relatively high concentrations, exceeding a certain critical value. Furthermore, it seems that, at any given level of B-9 applied to plants, the amount of this compound reaching the shoot cells was a function of the method used. The internal concentration attained in the case of spraying with the highest B-9 level appears to have exceeded the critical value, thus the stem elongation was then retarded.

It might be pointed out further that a great deal of research showed the suppressing effect of B-9 on dry matter accumulation in plants, a type of finding with which the results obtained at the fruit maturation stage, when using high levels of this compound, are in agreement. Amongst the publications available in this respect are those of (Sciuchetti 1967) on *Datura innoxida* and (Mitlehner 1968) on *Chrysanthemum morifolium*. Yet, in our study, the low B-9 concentrations were shown to lead to an increase in the dry weight. That a given growth inhibitor can stimulate growth at low concentrations, whereas at high concentrations growth is inhibited, has been reported by James—Sciuchetti (1964).

In addition, it might be pointed out that, according to our results, there were certain instances when a given treatment could affect the various growth characters of plant differently. This was obvious when considering the response of both height increase and dry matter accumulation in stems in the case of soaking the seeds in the high B-9 concentration. As previously mentioned, the former character appeared to be positively affected, whereas the reverse was true with regard to the latter one. The possibility that the dry weight per unit length of stem could be reduced compared to the control due to B-9 application has been reported by Mitlehner (1968).

Table 4

Dry weight of D. metel plants (g/plant) as affected by B-9 treatments

Developmental stage		Late vegetative growth		Flower-bud opening		Fruit maturation	
Plant organ	B-9 conc. (ppm)	Spraying	Soaking	Spraying	Soaking	Spraying	Soaking
				1970 season			
Leaves	0	2.6	0.9	7.4	4.6	9.2	9.8
	250	3.1	0.9	7.4	6.3	19.8	11.1
	1000	2.7	1.2	—	5.0	11.2	9.9
	4000	1.1	0.9	5.7	5.0	8.4	8.1
	L. S. D. at 5% level	0.4	N. S.	N. S.	1.0	2.8	N. S.
Stems	0	0.5	0.2	3.3	1.9	7.1	7.2
	250	0.7	0.2	3.4	3.1	17.0	7.8
	1000	0.6	0.3	—	2.8	14.5	7.5
	4000	0.2	0.2	2.0	2.2	7.6	6.7
	L. S. D. at 5% level	0.3	0.1	0.4	N. S.	1.9	N. S.
Roots	0	0.6	0.2	3.1	1.9	6.2	5.4
	250	0.8	0.2	2.9	3.0	8.0	5.6
	1000	0.7	0.3	—	2.6	6.8	5.5
	4000	0.3	0.2	2.8	2.5	4.7	3.7
	L. S. D. at 5% level	0.2	N. S.	N. S.	N. S.	1.7	N. S.
				1971 season			
Leaves	0	3.6	2.4	8.2	7.1	7.4	7.5
	250	4.0	3.3	8.8	12.4	8.2	16.6
	1000	3.6	3.7	8.3	8.0	8.1	9.4
	4000	3.5	3.1	7.4	7.3	5.0	5.2
	L. S. D. at 5% level	N. S.	N. S.	N. S.	3.0	1.8	2.8
Stems	0	1.9	0.8	6.9	4.2	9.1	10.2
	250	2.6	1.6	7.8	9.4	11.3	22.3
	1000	2.1	2.0	7.0	5.8	9.1	12.6
	4000	1.6	1.4	5.7	4.7	6.1	6.9
	L. S. D. at 5% level	0.7	1.0	N. S.	0.8	1.9	1.6
Roots	0	1.5	0.6	5.4	3.3	6.4	7.0
	250	2.9	0.9	7.3	5.2	8.4	10.6
	1000	1.5	1.6	7.3	3.6	6.4	7.9
	4000	1.3	1.1	3.8	3.5	4.6	4.0
	L. S. D. at 5% level	N. S.	N. S.	1.5	0.9	1.6	1.0

Table 5

wDry eight of D. metel plants at fruit maturation stage as of control, i.e. 0 ppm as affected by B-9 treatments

Plant organ	B-9 conc. (ppm)	1970 season		1971 season	
		Spraying	Soaking	Spraying	Soaking
Leaves	250	215.22	113.27	110.81	221.33
	1000	121.74	101.02	109.46	125.33
	4000	91.30	82.65	67.57	69.33
Stems	250	239.44	108.33	124.18	218.63
	1000	204.23	104.17	100.00	123.53
	4000	107.04	93.06	67.03	67.65
Boots	250	129.03	103.70	131.25	151.43
	1000	109.68	101.85	100.00	112.86
	4000	75.81	68.52	71.88	57.14

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FORUM

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PÁL, GY.: **Besides yielding ability it is resistance to infectious fungi that primarily determines the yield of a wheat variety today. Should — in your opinion — resistance to infectious fungi be genetically incorporated in the wheat varieties of the future or should only the yielding be increased, leaving the control of infectious fungi to plant protection, when it would be solved by using chemical agents, taking into consideration the financial aspects of the latter?**

BALLA, L.: Complex resistance will have to be built in to the wheat variety of the future, which will then make it possible to grow wheat without chemical control. Of the wheat diseases prevalent in Hungary, the development of complex resistance to powdery mildew and stem and leaf rust is both theoretically and practically possible. Foot diseases are more difficult to overcome because of methodological problems.

Chemical plant protection is a necessary evil in agriculture, which must be avoided as much as possible. In fact, for the fungal wheat diseases occurring in Hungary no efficient, economical methods of chemical control are known. These methods have not been developed

a) because the resistance level of the present varieties enables reliable productiont
b) for reasons of environmental and human toxicology,
c) due to the impracticability and expensiveness of control.

Results attained in wheat breeding during the last few years also represen, progress in breeding for resistance. The wheat variety Martonvásár 5, for example, is only slightly infected by powdery mildew, and the newer varieties are expected to be increasingly resistant to disease.

BEKE, F.: In the period to come yield reliability will play an increasing role beside potential yielding ability. Pathogens that can be controlled through seed dressing (*Ustilagines*, *Fusarium*, early powdery mildew, etc.) do not represent a breeding problem, but in the control of those pathogens which appear in the second half of the vegetation period, breeding for resistance will always have a part to play. On large areas, with a narrow time factor, overall protection becomes uncertain even at a high technical level and using large quantities of materials.

BELEA, A.: The conditions under which hereditary properties are manifested have lately become known in an increasing number of cases, and the correlation between their development and the environmental conditions has been disclosed. Many diseases which damage wheat and the inheritance of their biotypes are known. In my opinion, a still greater emphasis should be laid in the future on genetic methods of developing disease resistance in the new varieties (specific and generic crossing, addition and substitution, mutation, etc.).

Chemical substances are not likely to ever give perfect protection against infectious fungi. In these days, when environmental protection is an urgent problem all over the after-effects of chemical agents must be kept in mind as well as the financial aspects of this method of diseases control.

BÓCZ, E.: In the course of breeding for resistance higher biological resistance to fungal infections has to be incorporated in the future wheat varieties. Unfortunately, protection with the chemical substances now available is still unsuccessful.

CSONTOS, M.: In breeding winter wheats continued emphasis should be laid on resistance to infectious fungi, besides increasing the yielding ability. The advantages of varieties resistant to fungal infection can be grouped as follows:

a) The present disease control technology does not yet give full protection. It needs further improvement. Seed dressing, as well as spraying during the vegetation period, both simultaneously with weed killing and at the time of flowering, are at present the most important methods of plant protection. These operations do not ensure sufficient protection in every case (e.g. if the stand is too dense, if the environment is too hot and moist, or if there are unfavourable weather conditions). New chemical substances should be tested, the effectiveness should be increased, and the way in which these more efficient pesticides are applied should be improved. If chemicals of higher efficiency are used the frequency of mechanical plant protection work may be decreased. These trials and the introduction of new chemicals require lengthy and expensive research which can be dispensed with by using resistant varieties.

b) The solution of the ever more urgent problem of environmental protection is extremely important and would be greatly promoted by a reduction in chemical disease control.

c) Yield averages characteristic of the varieties are more reliably stabilized by using resistant varieties, since even the most perfect plant protection technology might fail in the case of unfavourable weather conditions. But it is under unfavourable weather conditions that infections occur most readily, and this always results in yield reduction. It follows that, though breeding for resistance takes a great deal of time, the realization of resistance to fungal infection will involve a stabilization of yield averages and a reduction in the outlay for chemicals, thus making it more favourable than chemical disease control alone. Therefore, in my opinion, the above method is the right solution.

Erdei, P.: The utilization of genetically established yielding ability in wheat varieties is determined — though not primarily — by their resistance to infectious diseases. One of the main objectives of breeders is to develop the genetic resistance of varieties by using various resistance sources.

Owing to the high variability of pathogenic fungi, however, race-specific resistance, which can be attained comparatively easily and quickly, does not give lasting results in most cases.

Overall resistance, though theoretically possible, is very difficult to realize in practice as it is a polygenetic character. The work is time-consuming, but the result are more lasting.

The numerous modern varieties known today are more or less tolerant to infection by pathogens, which is why this "form of resistance" appears in practical results.

Knowing the high variability of pathogenic fungi, the difficulty of developing resistance, the significant influence of the environmental factors which determine the susceptibility of plants and the higher susceptibility associated with increased yielding ability in the varieties, I am convinced that chemical plant protection is, and will continue to be necessary.

Kádár, A.: It would be advantageous if the high yielding wheat variety of the future were to possess resistance to all pests and pathogens. However, for well known reasons, this is unimaginable. In the case of a new variety I think it important to incorporate genetic resistance to those pathogens which cannot be controlled with the present methods of plant protection, or only with repeated treatments, e.g. rusts, powdery mildew, etc.

Kiss, Á.: One of the bases of yield reliability in wheat varieties is resistance or tolerance to infectious fungi. Plant breeders and geneticists will therefore play an extremely important role in developing the wheat varieties of the future. They will have the task of incorporating the minor and major resistance-carrier genes into the new resistant and tolerant varieties. This method, although it imposes a heavy burden on the geneticists and breeders, will be a cheaper and better solution than protection with highly efficient but very expensive chemicals which, in addition, cause environmental pollution.

Koltay, Á.: The work of wheat breeding will only be successful if higher yielding ability — the main objective of wheat breeding — is coupled with resistance to disease. Varieties resistant to all pathogens cannot be imagined, but the breeders must certainly try to attain resistance at least to diseases which cannot yet be controlled with chemicals. Occasionally the resistance of the variety, even when genetically incorporated, is only temporary, because a new race of the pathogen usually develops from which protection on a genetic basis is no longer ensured. In spite of this, wheat breeding should make every effort to produce varieties in which higher yielding ability is coupled with increased resistance, particularly to diseases which can be controlled chemically only to a limited extent, if at all.

Experience shows that the disease resistance of wheats is highly varied, indicating that resistance can be genetically incorporated in the variety. Protection from diseases which cause much trouble in certain years (*Fusarium*, *Cercosporella*, *Helminthosporium* etc.) is only possible at present with resistant, or at least tolerant varieties. The possibilities of controlling many other diseases are also limited and very expensive, so genetic resistance to a great variety of fungal diseases incorporated in the new varieties would be a promosing solution to the wheat growing problems.

KÜKEDI, E.: Resistance to fungal diseases must be incorporated in the wheat varieties of the future. Resistant and tolerant varieties increase the reliability and economic efficiency of production and decrease the differences between the yield averages of plots and farms. The incorporation of resistance is also justified by the changed cultural practices. The high number of weed seeds falling to the ground, the large volume of straw, stubble and root remains, the unnecessarily high rate of nitrogen fertilization, the dense stands, etc. all provide, directly or indirectly, favourable conditions for pathogens, particularly for infectious fungi. The danger of epidemics is further increased by incorrect cultural practices and weather favourable to fungal pathogens. According to the wide experience of researchers and farmers, varieties susceptible to the fungal diseases most frequent in Hungary (*Cercosporella herpotrichoides* Fron, *Erysiphe graminis* DC. f. sp. *tritici* Em. Marchal, *Fusarium* spp., *Ophiobolus graminis* Sacc., *Puccinia graminis* Pers. f. sp. *tritici* Erikss et Henn) suffered considerable damage in the rainy springs of 1970 and 1975. In these two years the national yield averages were 5.8 and 5.3 q/ha lower than in the previous year. In years with dry springs (1971, 1973, 1976), on the other hand, the yield averages showed an abrupt increase, due mainly to the absence of infection by fungi. True, in dry years weeds do not cause as much damage either, and even harvesting losses are smaller, nevertheless, the highest yield losses can be attributed to fungal pathogens.

The easiest, most reliable and most economical way of protecting plants from fungi is to grow resistant and tolerant varieties. More than one of the currently grown varieties owes its popularity not only to its high yielding ability but primarily to its disease resistance. Other varieties (Bezostaya 1, Avrora, Kavkaz and their derivatives), on the other hand, are being replaced mainly because of their susceptibility to diseases, although they have some highly valuable properties. Reliability of yield is considered to be a very important requirement in practice.

Breeding for nothing but yielding ability does not satisfy the demands of the farmers. New varieties are expected to be resistant, or at least tolerant, to the most frequent fungal diseases. However, resistance or tolerance to all fungal diseases cannot as yet be genetically incorporated in the new varieties, so it will be impossible to dispense with chemical control. Nevertheless, it would be wrong to rely exclusively on chemical plant protection. The problem can ultimately be solved by growing resistant varieties and by utilizing the possibilities of agrotechnical and chemical disease control, that is, by integrated plant protection.

LÁNG, G.: Resistance to the major diseases has always been and will remain in the future a very important task of wheat breeding. With the increasing intensity of production it will become imperative for wheat varieties to be resistant, because this is one of the bases for attaining reliably high yield levels. The importance of chemical control is also on the increase, but this can only be applied efficiently and economically if the cultivated variety is not susceptible. It is thus a mistake to consider resistance breeding and chemical plant protection as alternatives.

LELLEY, J.: The most efficient method of protection against pathogens is prevention. For the time being there are no fungicides with which the appearance of stem rust, leaf rust and powdery mildew can be prevented, although these are the most dangerous pathogens of wheat. The results of experiments performed so far are not very promising. Chemicals can only be used against the pathogens mentioned when the disease symptoms have already appeared. This means that intervention must be carried out in a very short time on a large area, which involves technical difficulties and considerable expense, while the result is not at all certain because the weather may prevent the development of the protective effect. It must also be considered whether it is wise to increase chemization any further.

Hereditary pathological resistance is, on the other hand, an efficient means of prevention, and does not contaminate the environment. There is no inverse correlation between the degree of resistance and yielding ability and other economic properties. The pathogens change, however, so permanent success can only be expected with well-con: sidered and organized, continuous work. Hereditary resistance is only efficient if the genetic changes in the pathogens are followed with constant attention, and if the trend of the change is forecasted through international co-operation. In this case, with the help of "multiline" cultivars composed of nearly isogenic lines and resistant to various rceas the damage can certainly be prevented.

Breeding for resistance is the most efficient and economical way of controlling the major wheat diseases. Hereditary resistance will only be replaceable by fungicides when simple seed dressing methods able to protect the plants against the above pathogens throughout the vegetation period are available. The probability of such control is relatively low. And even if it were to succeed, the question of whether the fungicides are quite harmless to the health of the consumers ought to be carefully considered.

NAGY, B.: In future production an increase in the yielding ability will naturally be a basic requirement. At the same time, mechanizability — or to express it in a more complex way: "industrial technologizability" is indispensable with the new varieties. For these two reasons the gene bank available to the breeder will become more and more restricted until the possibility of genetic or cytoplasmic manipulation relieves it. This means that breeding for resistance must be exploited parallel to plant protection, including continual intervention and advice by epidemiologists, in the future too. The resistance of the wheat variety to the following pathogens will remain an absolute necessity:

1. fungi whose rate of multiplication (epidemiologic "r" value) requires an extent of protection that cannot be practically attained with pesticides (e.g. in the case of rusts, in periods of epidemics the "r" value of 99 requires infinite technological efficiency on the basis of the Van der Plank formula);

2. pathogens whose "r" value is normal, but owing to their way of life no suitable method or means of control are available, e.g. Fusarium, etc. On the other hand, resistance to diseases (e.g. covered smut which can be reliably and economically controlled is not absolutely necessary, only desirable.

The demand for resistance in the case of the above two groups of diseases can only be lessened if systemic biochemical materials with which resistance can be artificially induced in the whole plant, become available to the breeder. Until then resistance must be a precondition for registering a variety.

PETRÓCZI, I.: In my opinion the cooperation of wheat breeders in the preventive control of phytopathogenic fungi is highly important. *Puccinia graminis* epidemics have ceased, the damage caused by *P. triticina* has become more moderate, and even *Erysiphe graminis* causes no serious damage any longer. However, breeding for resistance to *Tilletia foetida*, *T. intermedia*, *T. caries* and *Ustilago tritici* is still not allowed. The control of the *Tilletia* group has been solved by using seed dressings (Quinolate 15 and Fundazol), which do not damage the environment. The damage done to flowers by *Ustilago tritici* — pathogen spread via the seed — can be prevented with absorbable fungicides. Quinolate V—4—X, a preparation widely used in seed production, fulfils the practical requirements in every respect.

By growing resistant (tolerant) varieties and exercising chemical control the powdery mildew of cereals, and *Fusarium* and *Alternaria* infections of the spike, which are causing more and more serious problems, can be overcome. The genetic incorporation of resistance to fungi of the *Fusarium* sp. is thus justified.

By seed dressing and adequate cultural practices foot-diseases in young wheat plants can be prevented. To protect against leaf spots caused by *Septoria tritici* and *S. nodorum* the wheat stands should be sprayed (with Fundazol + Dithane) on one occasion each.

In the course of our investigations we found that the *Fusarium* infection of wheat was not significant in the last decade. Thus, the necessity of a thorough study of the intensive varieties naturally arises, since a considerable proportion of the commercially produced intensive varieties are bald wheats and grow upright spikes. At the ripening stage of the spike the rainwater infiltrates between the spikelets and does not easily evaporate from there. In slightly bending varieties a similar situation does not occur, because the awns of the loose spikes lead the water away.

The hypsophylls (glumes, awns) on the spikelets play an important role in the Fusarium infection. The orista, the appendage of the awn, varies with the variety. Its surface is bristly and therefore rough to the touch when stroked towards the tip. Its physiological role has not been clarified. Many authors consider it important in the water balance of the wheat plant. The results of experiments prove that bearded wheats evaporate 1.2—1.5 times more water, while those divested of their awns have difficulties in leading off the rain water and the moulding of the grain increases. However, it is only in seed production that fungicides can be applied by spraying at the stage of full ripeness. The protection of the environment and the possibility of chemical residues must be considered in wheats grown for eating and feeding purposes.

POGÁCSÁS., GY.: To increase the genetic yielding ability in the different wheat varieties and make it realizable is a fundamental duty for wheat breeders. It may be that there is a negative correlation between yielding ability and resistance to fungi, but even if this is so, we cannot give up increasing the yielding ability genetically. In my opinion, it is easier and quicker to create the chemical, technical and organizational conditions of protection against fungi, than to achieve genetic resistance. In addition, the development and propagation of resistant varieties take 6—10 years. At the present rate of economic acceleration the farms wish to solve the problems in a shorter time.

Furthermore, in recent years new biotypes (races) of fungi have appeared which cause damage to previously resistant varieties too, and in certain years formerly insignificant fungal diseases *(Septoria)* have caused damage. Moreover, varieties originating from crosses in which Bezostaya 1 is one of the parents become susceptible to powdery mildew in a few years. Knowing these facts it can be established that besides breeding for resistance the agrotechnical (stubble burning, right succession of plants, soil cultivation, healthy seed) and chemical methods of plant protection must be included in wheat growing technology even if they involve an increase in cost.

ROMÁNY, P.: Besides increasing the yielding ability breeders should endeavour to make every effort to attain the highest possible resistance in producing new varieties. Chemical plant protection is very expensive and requires high technical skill, while the appropriate result in many cases is uncertain. It is well known that wheat may be infected by various fungal diseases. Successful protection against them at different periods and using various methods could only be realized at great expense. In the case of resistant varieties the complicated and expensive operations of chemical control can be dispensed with, or at least greatly reduced.

ROSTA, K.: The genetic incorporation of resistance to stem or black rust and leaf rust is necessary.

The Fusarium spp. is primarily a soil-borne pathogen, therefore the most reliable means of protection against it is breeding for resistance.

Resistance to powdery mildew, dwarf bunt and loose smut can also be improved genetically.

Besides increased yielding ability, resistance to disease is an important objective for the breeder. Genetic resistance is of extraordinary importance for the reliability of yield, the preservation of soil organisms, the protection of the environment, and last but not least, for economic efficiency.

In spite of all this I think that genetic resistance to all pathogens is difficult to incorporate into a variety together with high yielding ability. Chemical agents will therefore be used in plant protection for a long time ahead.

SEMJÉN, I.: According to our present knowledge the chemical control of infectious fungi in wheat can be reliably solved only with great difficulty and at high cost, if at all. The fungicides (Fundazol, Thiovit, Morestan, etc.) applied against powdery mildew *(Erysiphe graminis)* on our farm did not give protection to certain wheat varieties (Bezostaya Kavkaz, Avrora). Varieties susceptible to disease are gradually withdrawn from production in spite of their excellent yielding ability. It is only by genetic means that this problem can be satisfactorily solved. Resistance to certain fungi has already been established in some varieties. Here I am thinking, for example, of the tolerance of Libellula and Sava to powdery mildew. In 1976 a serious powdery mildew infection occurred on our farm in a grade I propagation population of Bezostaya 1. At the same time Libellula sown in the same plot and separated only by the adjoining row remained practically free of infection under completely identical conditions. It was probably mainly for this reason that the yield of Libellula was 63 q/ha, and that of Bezostaya 41 q/ha. It was mainly due to the high yielding ability of Libellula that the farm attained an average yield of 57.4 q/ha in 1976.

In my opinion, resistance to fungal diseases should be genetically incorporated in the variety even if this results in a certain degree of reduction in the potential yielding ability. Naturally, I am not thinking of a disproportionate decrease in yielding ability. This is certainly a feasible, if not an easy approach.

I should like to say a few words about what in my opinion is one of the most efficient agrotechnical methods of preventive protection against fungal diseases in wheat. It is a well-known fact that the development, distribution and damage of any disease depend on the state of environmental and susceptibility factors. According to my experience, keeping to an optimum sowing time (10—25th October) is one of the most successful methods of prevention. Under Hungarian conditions sowing too early (in September) is very dangerous. Superabundant stands provide highly favourable conditions for fungal diseases to spread. The damage will be particularly great when early sowing is coupled with a high rate of autumn nitrogen application. According to our most recent experiences wheat should be given basic (phosphorus and potassium) fertilization applied if possible to the forecrop. Nitrogen fertilization is only needed in autumn if the forecrop is very bad. Every effort should be made to avoid superabundant and overdense wheat stands in autumn. Development should be enhanced with a higher rate of nitrogen top dressing (120—160 kg/ha) at the end of winter (February), followed by smaller doses (60—70 kg/ha) repeated according to need (April and May). In this way the conditions will not be favourable for the development of fungi. Wheat must be supplied, but not oversupplied, with nutrients. Naturally, these methods and observations also depend on various meteorological factors. The weather should be followed with close attention and crop production should be accommodated to it.

As long as reliably resistant varieties are not available increased care must be taken in applying agrotechnical methods for preventing and controlling fungal diseases. Infection should be reduced to as near a minimum as possible.

SZALAI, L.: Although from an economic point of view the question may be unimportant, nevertheless those wheat varieties which require only minimum protection should be give preference. The chemical control of infectious fungi is not, in my opinion, the right solution, not only because of the surplus expense it involves, but also because it threatens both the environment and the purity of products intended for human consumption. Every effort must be made to prevent harmful chemical substances from entering the human organism. It must be taken into consideration that wheat varieties with a genetic resistance to fungi provide better protection against mass infection by fungi.

SZALAY, D.: To produce varieties resistant or at least tolerant to diseases and in some cases pests is one of the most important tasks in plant breeding today. Intensive production creates favourable conditions for most pathogens. The actual yield loss per unit area caused by the diseases increases parallel to the rise in the yield averages. The importance of breeding for resistance, including research directed at producing resistant varieties, will therefore grow in the future. Parallel with an increase in yielding ability breeding must be aimed at giving a genetic basis to disease resistance, as far as possible to all major pathogens, in the prospective varieties. The efficiency of breeding wheat for resistance is proved by the existence of new varieties resistant to powdery mildew, leaf and stem rust. Genetic protection against Fusarium, and against root and foot diseases in general, is an increasingly urgent task for wheat breeding. In certain years these pathogens cause substantial yield losses. Under Hungarian conditions damage caused by smuts must be reckoned with, and reliable protection from these can only be attained through hereditary resistance. Although infection by covered smut can be prevented by the generally utilised seed dressing, the susceptibility of the variety still cannot be ignored. On an infected area susceptible strains develop a considerable number of diseased spikes even after treatment of the seed.

From the listing of the major diseases it can be seen that the development of high yielding wheat varieties which also possess overall resistance is a very complex task. A perfect solution can only be expected in the distant future. Further difficulties are caused by the genetic variability shown by the pathogens. As a consequence of the appearance and spreading of new races, a resistant variety may become highly susceptible within a few years. (Fertődi 293 lost its resistance to leaf rust after the mass occurrence of race 77. With the distribution of the powdery mildew races 4, 26 and 52 the varieties Kavkaz and Avrora, both resistant till then, became highly susceptible.)

Ensuring disease resistance in the varieties thus requires permanent, continuous research. These tasks call for good research teams with close working relations, including international co-operation. In Hungary the first steps in breeding wheat for resistance have been taken during the past decades. However, considering the amount of theoretical research which is indispensable, the mobilization of considerable intellectual and financial forces is till required if the work is to be successful.

The preference given to the genetic establishment of disease resistance is sufficiently justified by environmental protection considerations. Apart from this, the adequate development of research will cost in a decade as much as spraying the 1.3 million ha wheat area on a single occasion does.

This emphasis on the importance of complex genetic protection in the varieties does not deny the significance of phytopathological investigations (without which there can be no talk of breeding for resistance), nor the necessity and national economic importance of practical plant protection. In each case when a major attack by pathogens (or pests) is expected and it is possible to fight it off with chemical substances, the neglect of chemical control is inexcusable. The total cost of spraying or dusting is much less than a yield loss even of only a few per cent.

SZÁNIEL, I.: Breeding must be aimed both at improving the yielding ability and the quality (baking quality, protein content, etc.) and at increasing the genetic resistance. However, no overall resistance to the different fungus species and their races is likely to be attained, at best tolerance or pseudoresistance. Such varieties may still exhibit high yielding ability and/or excellent quality. Consequently, a compromise will be made when registering a variety. Any problem left unsolved genetically by the breeders in a given variety otherwise suitable for production has to be dealt with by the plant protection experts taking the economic aspects into consideration.

TOMPA, GY.: Yield losses have been almost regular for several years owing to the damage caused by plant pathogens. The average loss per ha is as much as 1500—2000 forints a year, which largely corresponds to the nutrient input for wheat.

On a national scale losses of this kind amount to some 2 thousand million forints.

This is why the control of pathogens (particularly fungi) cannot be just a campaign or a periodical activity, nor is it the exclusive task of the farms. Every organization directly or indirectly interested in agriculture must take an active part in this complex work. The final aim is to increase the yield of wheat through the destruction of pathogens.

I think I made my point of view on the question quite clear in the last sentence, when I suggested that in the destruction of pathogens, preferably by preventative methods, lies the main hope of increasing yields.

In my opinion a permanent increase in yielding ability combined with perfect resistance can only be maintained in a new variety for a short period, and must not be regarded as a task exclusively for breeders. If this highly complex problem were dealt with only by breeders, we should have to wait for a long time before the product of the breeding programme — a new high yielding variety — could be introduced into commercial production. It is worth mentioning that if, for example, a variety capable of producing 2 q more than the other varieties and grown on only 5% of the total wheat area of the country could be introduced into cultivation just one year earlier, this would mean some 13,000 tons surplus yield on a national scale, i.e. about 50 million forints in inland trade.

Permanent high yields can be attained by improving details. The primary task facing breeders is therefore to find varieties which, irrespective of the pathogens, give larger yields than their predecessors and are able to produce record yields.

Though it would be wrong to make a generalization, still the correlation between higher yielding varieties and the appearance of pathogens is apparent, even if some high yielding varieties show resistance for several years.

This also holds true inversely: extensive varieties, which have been grown for a long time and are still produced in small quantities, are sufficiently resistant to certain fungi even today.

Any compromise made by the breeder in developing a new variety involves giving up something. In the present case, genetic resistance of debatable duration can usually be ensured only at the expense of the yield surplus. And even if resistance should happen to develop, there is nothing to prevent another race from appearing and causing the same or even more damage.

Tasks related with plant protection, on the other hand, must be considered from a completely different point of view.

Unfortunately, apart from seed dressing, which is carried out with varying success, the majority of farms either take hardly any steps against the plant pathogens appearing during the vegetation period, in the hope that the variety is sufficiently resistant, or the necessary pesticides are unknown or unobtainable.

It often happens that the appearance of the pathogen is noticed too late, or its importance is underestimated and control operations are not carried out because of the expensiveness of protective measures.

Some climatic factors occurring in certain years are known to exercise a great influence on the extent of infection and damage. A dry June and July (as in 1976) may hinder the damaging activity of the fungi so much that there is hardly any yield difference between treated and untreated crops. The experience obtained in such years may lead to the wrong conviction that the control of pathogens during the vegetative period unnecessarily increases costs, as it does not yield any significant difference.

If, on the other hand, late spring is rainy and is followed by a humid (foggy) June (as in 1975) the pathogens regularly appear, and only chemical treatment carried out in due time with the right material and method is able to protect the plants from fungi at the most critical stage, thereby proving the importance of plant protection.

The breeder's main task is to produce new varieties yielding more than their predecessors owing to the potential yielding ability of the variety. Breeding should thus be aimed primarily at increasing the yielding ability.

Prevention should be the main aim of plant protection, but both mechanical and chemical control operations should be carried out, and that not as a campaign, but in a premeditated, systematic and scheduled manner in order to guarantee yield reliability.

TULCZ, I.: The breeders must definitely incorporate genetic resistance to infectious fungi in the wheat variety of the future, since according to our present knowledge plant protection cannot be solved with the available fungicides, especially when the weather conditions are favourable for the development of fungal diseases.

The effect of the pesticides available, in other words the time for which they provide protection, is so short that under unfavourable weather conditions spraying and other plant protection operations should be repeated every few days if they are to be successful. In this case the cost implications cannot, of course, be neglected. In my opinion it will be a long time before these plant protection operations can be carried out by aircraft over the total wheat area of Hungary, which covers more than 30% of the country's arable land.

It has lately been pointed out quite clearly in practice that in varieties more or less resistant to fungal diseases the latter do not cause any substantial yield loss even under unfavourable weather conditions.

Protection is undoubtedly needed even in the case of varieties resistant to fungal diseases, especially when necessitated by the weather or by other factors, e.g. the pre-crop, since full resistance to all pathogens has not been attained so far.

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PÁL, GY.: **Owing to aerodynamic stress the lodging resistance of wheat varieties depends, among other things, on the height of the plant and the quantity and quality of the supporting elements. What do you think the solution should be with the future wheat varieties: to reduce the aerodynamic stress by producing dwarf varieties, or to leave the plant height unchanged and increase the stiffness of the straw instead?**

BALLA, L.: The future wheat varieties must have short, strong straw if they are to be suitable for mechanical harvesting even with 80—100 q/ha yields, and at the same time to maintain their adaptability to unfavourable edaphonic and climatic conditions (large root system) and to attain a height sufficient to force down the weeds. These three factors must be brought into harmony, so it is reasonable to shorten and strengthen the stalk. According to our present knowledge the optimum height is 70—80 cm. It is, however, probable that under extreme conditions where the yield is less than 50 q/ha e.g. in sodic or eroded soils, varieties with longer (90—100 cm) stalks will continue to be required.

BEKE, F.: Dwarfing does not only serve to overcome aerodynamic stress. The water supply is a bottleneck in agricultural production. In long-stalked wheats the grain-straw ratio is 1 : 3. More productive water utilization can only be attained with short-stalked wheats with a grain-straw ratio of 1 : 1.5 or 1 : 1. Grain should make up nearly half of the dry matter produced. In long-stalked wheats lodging may cause a 10—30% yield loss. Dwarf wheats thus carry one of the factors of yield reliability.

BELEA, A.: In my opinion, dwarfness is not the principal solution for resistance to lodging. Increased emphasis should be laid on a medium high, flexible, lodging-resistant wheat type. The advantage of this type, among other things, is that it provides the basic material for the farmyard manure required for cellulose manufacture and for organic matter replacement. Dwarf wheat production is expected to spread, particularly under irrigated conditions in special growing districts.

CSONTOS, M.: It is reasonable to try to increase resistance to lodging by relieving the aerodynamic stress, that is, by developing dwarf varieties.

The up-to-date livestock technologies require less and less straw, and the industrial processing of straw is still confined to a few regions, so there is no justification for increasing the volume of straw.

ERDEI, P.: The wheat of the future or rather its ideotype, will be primarily determined by the economy of material transport within the plant, nutriet utilization, etc. These requirements already favour dwarfing, and this will be even more so in the future. This, naturally, does not mean that stalk strength can be neglected. On the contrary, outstanding results can be attained by coupling the two properties.

Dwarfness, has, however, physiological limitations. Below a certain height many properties of wheat (yielding ability, disease resistance, drought tolerance, etc.) deteriorate because they are in close correlation with stalk length.

At present the semi-dwarf (70—80 cm) forms are those in which the desired shorter stalk is favourably coupled with high yielding ability and other advantageous characters. But even in these forms stalk strength is a primary requirement.

KÁDÁR, A.: In wheat varieties which give higher yields than those currently cultivated, dwarfness and stalk stiffness should, in my opinion, be aimed at during breeding, up to a limit where a yield-decreasing effect is felt.

KISS, Á.: In breeding wheat for resistance to lodging both possibilities should be utilized. The present high yielding, firm-stalked wheat varieties are 75—100 cm high on average, some 30—40 cm shorter than the earlier wheat varieties. It seems that further dwarfing would adversely affect the yielding ability. According to our present knowledge, research should be concentrated on increasing the stiffness of the stalk. It is, however, genetically possible to produce types with firm stalks 50—70 cm in length. In my opinion, in the coming 10—20 years the stalk length of high yielding wheat varieties will continue to shorten, with a simultaneous increase in the firmness and flexibility of the stalk and an improvement in the disease resistance.

KOLTAY, Á.: The lodging-resistant wheat variety is a basic requirement for present growing technologies. Even dwarfness does not mean a reliable solution, because commercially produced varieties considered semi-dwarf also lodge if the stands are much thicker than the optimum under climatic, precipitation and illumination conditions favourable for lodging.

Even if very short-stalked varieties free of the known unfavourable properties were produced by using the present definitely dwarf wheats as sources, this would be no solution for commercial production, since on areas overgrown by weeds these varieties could not be protected with the means available at present.

Commercial production now requires a variety with a relatively short (90—100 cm) stalk, and a favourable grain-straw ratio. Increased straw firmness is, naturally, a breeding objective of primary importance.

The use of retardants is also a highly efficient means of preventing cereals from lodging. With the right application of growth regulators (CCC, ETHREL, etc.) lodging in optimum density stands not higher than 100 cm can certainly be avoided, not to mention other advantages of using these chemicals. On these grounds we can safely say that decidedly dwarf wheat varieties are not demanded in commercial production as yet. If dwarf varieties of full value were to be successfully developed by overcoming the known difficulties, they would be particularly important under irrigated conditions.

KURUCZ, GY.: The plant height of wheat varieties is influenced among other things by the straw requirement of the farms. Straw processing methods (pellet production, cellulose production, etc.) that increase the demand for straw are spreading. Litter straw requirements cannot be neglected either, especially from the point of view of economic efficiency and environmental protection. The future wheat variety assortment should include dwarf varieties for farms with a low straw requirement, but for those where straw is needed a stalk length of 90—100 cm coupled with increased straw firmness must be ensured. The demand for plant height will thus vary according to the type of farm, so that apart from producing dwarf varieties, breeding must be aimed at increasing the stiffness of stalk.

LÁNG, G.: Most of the wheat varieties included in commercial production at present have moderately long straw. Owing to the higher requirements which will arise for stalk stiffness, the intensive wheats of the future must have somewhat shorter stalks. Simultaneous efforts should, however, be made to increase the stiffness of the straw. Very short-stalked, so-called dwarf wheats will not play an important role during the coming decades, and are not likely to be widely introduced until a breakthrough is achieved in the correlation between stalk length and root volume. In any case, dwarf wheats will primarily be of importance under irrigated conditions.

LELLEY, J.: If the national average wheat yield is to be further increased, the breeding of wheats with a traditional straw length must be abandoned. The necessary standing ability at the stand density and spike weight required for a national yield average of more than 30 q/ha can only be ensured with semi-dwarf (70—90 cm high) cultivars. It is not, however, enough to shorten the stalk; its standing ability must also be improved. This demand is justified by the increasing application of irrigation in wheat production. The shorter stalk renders a higher rate of fertilization and increased stand density possible and brings about a favourable change in the microclimate of the stands. The shortening of the stalk has an advantageous influence on the grain-straw ratio; nutrifient utilization will thus be more economical.

The climatic resistance of dwarf wheats with a stalk shorter than the semi-dwarf stalk length is uncertain owing to the shortness of the roots. For this reason the future of dwarf wheat production is not too promising at present.

Nagy, B.: In the classic (non-hybrid) wheat varieties resistance to lodging is a primary criterion. The genetic material available at present makes this possible. In other words, when registering wheat varieties stiffness of straw must be one of the main requirements.

Concessions can only be made in this matter if, particularly for prospective hybrids, the potential increase in yielding ability resulting from the hybridization makes it reasonable and financially sound to use regulators to compensate the intensive growth of the stalks natural in hybrids. That is, concessions as regards the tendency to lodge can only be made in the case of hybrids with a yielding ability several categories higher.

Pogácsás, Gy.: Breeding wheat for resistance to lodging has recently been carried out in two directions:

a) by reducing the plant height (dwarfing), and
b) by increasing the strength of straw.

Under the present economic conditions wheat is grown in Hungary for its grain yield, while the straw is only a by-product which is occasionally even burnt as useless in the field.

Farm experience shows that with short stalks even the heavy spikes that give large grain yields do not lodge.

Resistance to lodging should be aimed at both through dwarfness and through straw strength. The earlier the variety ripens the shorter its straw should be. In the 1976 variety trials the Italian varieties were very short stalked and at the same time very early (Trebo, Aquileia, Adria, etc.). The early variety Sava also has short straw. Libellula can be regarded as a medium tall variety. In my opinion even the late varieties should not have straw longer than 100 cm. In consider the reduction of stalk length to be the primary task, though breeding for straw stiffness must not be neglected either.

It should be noted that a late dwarf wheat can hardly be imagined, since by the second half of the harvesting period, if ripening occurs late, the weed plants become strong and suppress the dwarf wheats.

Romány, P.: Both foreign and Hungarian experiences show that as yet there are no varieties with long (100—110 cm), firm stalks which are also able to give large yields without lodging. According to the results obtained so far, the stalk length of varieties giving 50—60 q/ha without lodging does not usually exceed 100 cm.

In my opinion, stalk stiffness can and should be increased by shortening the stalk. A higher agrotechnical level of wheat production with a simultaneous increase in yield requires varieties with short, firm stalks.

Rosta, K.: In intensive wheat varieties, which utilize better the yield-increasing effect of fertilizer and which produce spikes with a larger number of grains and higher thousand-grain-weight, the danger of lodging is almost certain to increase.

Consequently, it is extremely important that the stalk stiffness should be increased. In my opinion, shortening the stalk is also necessary if lodging is to be avoided.

Dwarf wheats may raise many agrotechnical problems owing to their short root system and poor drought tolerance. The danger of lodging will, naturally, continue to threaten despite the shortening and strengthening of the stalk, if incorrect agrotechnics or improper fertilization are utilised or if the stands are too dense.

Szalay, D.: Increasing the resistance to lodging in wheat has lately become an urgent breeding task. Owing to difficulties in harvesting and because of the sometimes considerable yield losses (e.g. in 1975) the farms are looking for varieties with better standing ability than Bezostaya 1.

Resistance to lodging is determined by a number of factors. The requirements of wheat production can only be fulfilled by improving all the factors which favourably influence the standing ability of the plant. Besides the strength of the root system and the firmness and flexibility of the stalk, the height of the plant is a fundamental factor in developing this character. Without overemphasizing the importance of stalk length, it is obvious that wheats with the height of Bánkúti 1201 can no longer be grown in Hungary. In the sixties (up to a yield of 40—50 q/ha) the stability of Bezostaya 1 was acceptable. At present the wheat production systems, and in general the better farms, call for varieties able to stand under a yield of 80—100 q/ha. Only exceptionally can this type of wheat be higher than the variety Sava (plant height: 70—90 cm).

A reduction in the stalk length is inevitable primarily because of aerodynamic stress. It also plays some role in decreasing the extent of selfshading and developing a more favourable grain/straw ratio.

In efficient farms the density of wheat stands is adjusted to produce 500—600 spikes/m^2 or more. In dense stands of varieties with strong, thick and relatively long (90—110 cm) stalks (Kavkaz, Jubileinaya 50) the lower parts of the plants are shaded and the basal internodes etiolated. Apart from the fact that a microclimate favourable for the multiplication of pathogens develops in such stands, the development of the supporting tissues of the stalks is hindered. With varieties of this type denser stands cannot be sown without the danger of lodging.

The wheat varieties grown in Hungary incorporate about twice as much organic matter into the stalk as into the grain. I think that the desired 1 : 1 ratio of grain to straw can only be attained by types with short, sufficiently strong stalks which should be as thin and flexible as possible. This factor holds great promise of an increase in the potential grain yielding ability.

With the present combines wheats with stalks shorter than 60 cm cannot be harvested without loss (some of the spikes are not directed onto the cutting board by the guide-blade). The development of varieties with an optimum (about 65 cm) straw length, which also meet the requirements in other characters, is hindered by a number of factors. The overwhelming majority of the dwarf wheats have poor winter hardiness. Short straw is closely linked with reduced viability and low yielding ability. In addition, the stand height of the same variety may show a variation exceeding 20 cm depending on the growing site (including the level of cultural practices) and the cropyear. Low stands are easily overgrown by weeds. Thus, semi-dwarf (80—90 cm high) wheats are expected to be of importance for many years to come in the wheat production of Hungary.

SZÁNIEL, I.: Both solutions are probably feasible, though I would give preference to dwarfing. Short and at the same time form-stalked varieties are of extreme importance not only because they do not lodge, but also for many other reasons, such as the higher number of plants per unit area, more intensive fertilization, larger harvesting capacity of the combines, etc.

TOMPA, GY.: Stalk stiffness is an important factor as it prevents the wheat from lodging and increases the yield. Plants which lodge early, before grain formation, are exposed to a great diversity of fungal diseases, since the shading caused by lodging creates quite a different microclimate near the soil surface, much more humid conditions where the motion of the air is also highly restricted. If this state is maintained for a long time, and the phototropism of the plant cannot become effective because of various (mostly climatic) factors, then grain formation will usually either fail to occur, or only refuse grain will develop in the spikes.

Lodging may be caused by an excess of nitrogen in the NPK fertilization, thus over-satisfying the nitrogen requirement, which is important for wheat right up to ripening. The sudden growth in the stalk caused by the incorporation of the nitrogen results in a thinning out of the tissues, which is a direct concomitant of lodging. Perhaps it is worth mentioning that in lodged wheat plants the internodes are 15—25% longer than when a proper ratio of nutrients is supplied.

In the case of lodging another problem is caused by harvesting losses, even when the plants lodge after grain formation, when the crop has in fact been produced. Even with the most careful combine harvesting losses are unavoidable, as the cutting mechanisms leave a considerable quantity of spikes on the ground.

The response given by different wheat varieties to the sowing density depends on the length of the stalk. The varieties are not uniformly tolerant to dense stands. Long-stalked varieties are less tolerant to a plant number of 400—450/m^2, while those with shorter stalks can be sown to a plant number of 500—550/m^2 without the danger of lodging.

It is thus reasonable to raise the problem of stalk length in wheat growing. In my opinion the straw yield must always be taken into consideration, as it will be required both as litter in livestock breeding (returned to crop production in the form of nutrient) and as raw material for industry for a long time ahead. At the same time, I think an average stalk length of 60 cm should be sufficient, as this is long enough to cover the requirements mentioned above and short enough to prevent the plant from lodging.

In this way shorter upright stalks will provide a larger yield than long stalks lying on the ground unfit for harvesting.

As to the variety of the future, I see two possible solutions. One of them is to produce and introduce into commercial production high yielding varieties with the above mentioned average straw length. This is a task for breeders alone. The other solution is the regular application of CCC, which, according to Hungarian experience, has a stiffening effect on the stalk since it strengthens the tissue structure of the plants, and, in addition, exerts a positive influence on the yield-reducing effect of fungal pathogens (e.g. Cercosporella herpotrichoides). Nevertheless, it has not been widely used so far. According to our present knowledge, CCC application can be combined with herbicide distribution, so the cost implications are not significant, especially when compared with the resulting reliability of yield. It would be even better if the application of CCC could be combined with the distribution of basic fertilizer in a form enabling it to act through the soil and the roots of the plant.

TULCZ, I.: The higher rate of fertilization and the widespread introduction of mechanical harvesting have increased the demand for wheat varieties resistant to lodging. Shortening the stalk in order to increase its strength seemed to be an obvious solution to the problem. Even varieties considered to be firm-strawed are inclined to lodge when they have longer stalks. As an example the high yielding and, in my opinion, firm-stalked Jubileinaya 50 might be mentioned.

Breeders have to reduce the plant height to a certain extent in order to increase the resistance to lodging. Dwarfing is also justified by the necessity to protect the plants against fungal diseases. Objections to reducing the height can be raised on two scores: first, very short stalks may result in serious harvesting losses. It is known that certain meteorological factors may cause a 15—20% deviation in plant height. The problem is aggravated by the broadening of the cutting boards on the combines. On uneven ground losses occur in wheats with shorter stalks even when using the E 512 combine, especially during the harvesting of tillers. The other point to be considered is the value of the straw. With the increasing industrial utilization of straw its value is likely to rise.

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PÁL, GY.: **The replacement of varieties in wheat production has recently been too frequent, varieties have been chaged too fast. Is — in your opinion — the rapid change of varieties due to the deterioration of the wheat varieties and the discontinuation of hybrid vigour in varieties of hybrid origin, or are otherwise good varieties only replaced because the new varieties give larger yields?**

BALLA, L.: During the last fifteen years a change of variety has occurred twice in Hungary, first at the beginning of the sixties, when Bezostaya was introduced. This replaced the old-type Hungarian varieties and occupied about 80% of the wheat area. Together with the Hungarian variety Fertődi 293, which spread over some 15—20% of the wheat area, they supplanted practically all other varieties.

The second replacement took place in the early seventies, when the introduction of new varieties (Avrora, Kavkaz, Jubileinaya 50 and Libellula) confined the production of Bezostaya to some 25% of the sowing area. With them the range of cultivated varieties became wider.

The third change of variety is taking place at present. The foreign varieties — to start with, the Krasnodar-bred Avrora and Kavkaz — are being replaced by Hungarian, particularly by Martonvásár varieties. In 1978, when a sufficient quantity of seed will be available for the Hungarian varieties, the larger part of the sowing area will probably be sown to Hungarian wheats, with the foreign varieties partially or completely eliminated.

The replacement of varieties is justified primarily by the appearance of new high yielding varieties. A minor role is played by the degeneration of certain varieties (e.g. Avrora and Kavkaz), but the main reason for changing the varieties is the higher potential yielding ability of the new varieties. This is proved by the fact that in the early sixties Bezostaya 1, with an average yield of 36.7 q/ha over three years, was among the highest yielding varieties in the national variety trials (Fig. 1). Another variety, Fertődi 293, attained a similar level (the difference between the two was 0.1 q), but twice in the three years even this latter was exceeded by Bezostaya 1, which was thus placed first among the varities examined. During the last three years, however, Bezostaya 1 has yielded 52.7 q/ha on average in the national variety trials compared to 60.3 q produced by the best varieties, which thus exceed Bezostaya 1 by 7.9 q

(14.4%). With this yield Bezostaya 1 was placed 13th in 1974, 15th in 1975 and 14th in 1976 among the varieties tested, clearly showing that it was a case of falling behind rather than of degeneration.

In spite of its degeneration the case of Kavkaz is similar; in the first three years (1970—1972) it was first among the varieties tested with a yield of 49.2 q/ha, while in the last three years (1974—1976) its 54.1 q/ha average yield was only sufficient for the sixth place. If the new Martonvásár wheat varieties and prospective varieties (Martonvásári 5, Mv 23—73, Martonvásári 1, Mv 22—72) had not been developed in the meantime, Kavkaz would be the second best variety on the basis of a three year average. The deterioration is thus comparative, while fallback is obvious in this case too.

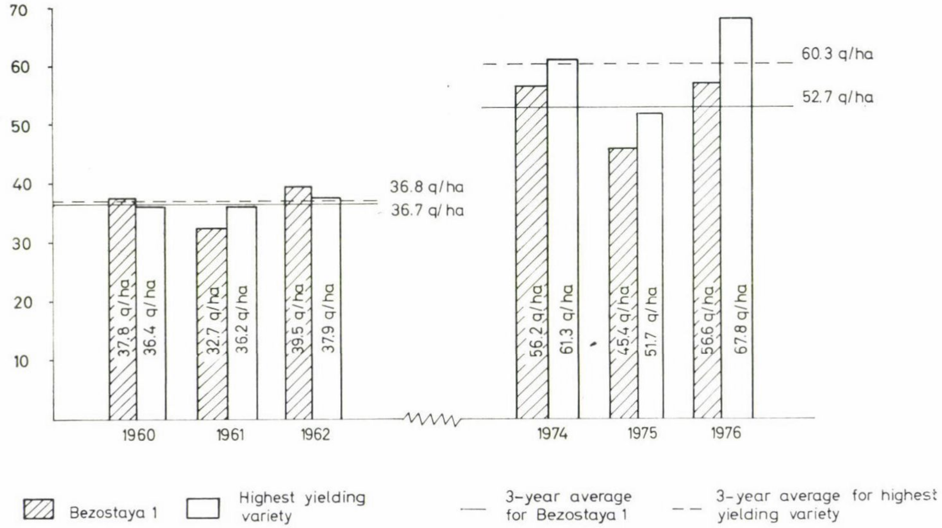

Fig. 1. Average yields of Bezostaya 1 and of the highest yielding variety in national variety trials

The degeneration of Kavkaz and Aurora can be traced back to their genetic vulnerability. When these cultivars were first produced they were resistant to powdery mildew and stem and leaf rust. Within a short time, however, after 2—3 years, new very aggressive powdery mildew races specialized to these varities appeared, so the varities previously resistant to powdery mildew became susceptible to the disease. Subsequently they also lost their resistance to leaf rust, as new biotypes of race 77 became specialized to these varities. The situation seems to be the same with respect to foot diseases, since they no longer produce as much as they did initially, even when powdery mildew infections are scarce and leaf rust does not appear. So they are susceptible to foot diseases at the same time.

The fallback of the varieties cannot be attributed to the discontinuation of hybrid vigour, as the latter is not likely to occur in varieties of hybrid origin introduced into cultivation 15—20 years after corossing.

Bátyai, J.: Wheat growing has made substantial progress in recent years in Hungary. New valuable varieties which meet the present production requirements and offer the possibility of attaining still larger yields have been introduced into commercial production. At the same time, by increasing the rate of fertilization from year to year, using more up-to-date machines and applying new cultural practices, the farms create conditions which can only be exploited with new, more up-to-date varieties.

New varieties are necessary because of the increased demand for standing ability, disease resistance and shorter vegetation period, which are all factors rendering the production more reliable.

This is confirmed by the percentage change in the areas sown to different wheat varieties in Szolnok County and their yield averages:

Percentage area and average yield of wheat varieties

	1974		1975		1976		1976/77
	%	q/ha	%	q/ha	%	q/ha	%
Bezostaya 1	37.0	37.8	27.6	35.00	24.5	35.00	17
Kavkaz	19.0	40.1	21.0	35.6	15.8	36.9	6
Jubileinaja 50	12.0	44.5	21.0	38.7	28.6	41.8	40
Libellula	8.0	45.9	11.0	40.8	11.9	44.1	21
Avrora	14.0	38.9	8.6	33.8	8.5	34.1	2
Rannyaya 12	6.0	35.0	2.3	35.6	0.5	40.2	—
Mv varieties	—	—	3.6	35.3	5.2	41.5	8
GK Fertődi	—	—	0.8	36.9	1.1	37.8	3
Sava	—	—	—	—	1.1	43.3	3
Others	4	—	4.1	—	2.8	—	—

The above table shows that the sowing area of Bezostaya has decreased from 37% in 1974 to 17% by 1976/77. The average yield did not change substantially during the three years examined.

The same declining tendency is seen with the varieties Kavkaz and Avrora, though their yield averages have fallen by 10—11% during the last two years. This tendency can be attributed to the fact that the susceptibility of the varieties Avrora and Kavkaz to various diseases has increased, and that, owing to their relatively long vegetation period, in droughty years their grains tend to shrivel, and therefore their production has become risky.

The sowing areas of the commercially produced varieties Jubileinaya 50 and Libellula have increased from 12 to 40% and from 8 to 21%, respectively. In the three years in question the yield averages of both varieties exceeded those of the above mentioned varieties by 15—20%, and Libellula was particularly resistant to diseases. Owing to its earliness there was rarely a yield decrease caused by shrivelled grains.

To sum up the experiences gained in Szolnok County: One of the reasons for replacing the varieties from time to time is the appearance of new, more reliably grown varieties. This is the explanation for the decrease in the sowing area of Bezostaya 1 in favour of such varieties as Libelulla, Mv 4, etc.

Another reason is the deterioration of certain varieties, manifested particularly in decreased resistance to disease and ultimately in a reduction in yield (Kavkaz, Avrora).

The change of varieties is thus a necessary process which ensures a continuous rising of the wheat production level.

BEKE, F.: The rapid replacement of varieties cannot be attributed to genetic deterioration. Its main cause is the appearance of a new biotype of some pathogen as a consequence of growing the same variety on large areas. Changes in the race spectrum and the rapid distribution of certain biotypes promotes the development and frequency of epidemics (e.g. in the case of Bezostaya 2, Burgas, Avrora, Kavkaz, Fe 293). New, more up-to-date varieties are playing an increasing role in accelerating the replacement of varieties.

BELEA, A.: The improvement in various factors influencing the efficiency of production (increased rate of fertilization, use of combines, etc.) has made it necessary to introduce intensive wheat varieties into commercial production. The well-equipped breeding establishments suggests the life span of the new varieties to be 5—6 years in general.

The rapid change of varieties is not primarily due to the deterioration of the wheat varieties and the discontinuation of hybrid vigour, but due to the susceptibility of the cultivated varieties to new pathogen biotypes. More efforts should be made to develop varieties with a wide range of genes for resistance. If we are in possession of a collection which, while of uniform type, contains different resistance sources, as e.g. in the breeding institutes of Australia, the United States of America and Canada, then each particular variety may have a much longer lifespan.

The deterioration of the varieties can be prevented by maintenance breeding. According to a survey made by the Headquarters of the Hungarian State Farms, the use of seed with a higher degree of propagation provides a yield surplus of 7—8.5 q/hectare compared to standard seed.

Bócz, E.: The rapid change of varieties in recent years has mainly been caused by the sharp decrease in their original yielding ability. The sudden reduction of yields is primarily due to the extensive spread of fungal diseases.

Csontos, M.: The change of variety in wheat production is satisfactorily explained by the higher yielding ability of the new varieties. The degeneration of the varieties does not usually necessitate a too rapid change, as it causes negligible yield losses. The disappearance of hybrid vigour cannot be spoken of in the absence of wheat hybrids.

Erdei, P.: The faster exchange of varieties currently witnessed is generally the consequence of the dynamically developing conditions for plant growing. Among the concrete causes for the exchange of varieties the most important is the appearance of higher yielding varieties which are also superior to their predecessors in other respect. They make far better use of the more intensive conditions.

There are also examples of varieties having been replaced or discarded due to their showing signs of biological deterioration within a short time, or to their losing resistance to disease.

Economic and commercial factors also motivate the rapid exchange of varieties. Reduced hybrid vigour or genetic deterioration have little if anything to do with it.

Kádár, A.: I regard the rapid change of varieties as the result of degeneration after 3—4 years of cultivation, the appearance of higher yielding new varieties and changes in cultivation methods.

Kiss, Á.: I do not think that the reason for the rapid replacement of varieties can be the degeneration of the variety, since varieties seldom deteriorate within five years. Earlier varieties are replaced before they become old because of the higher yielding ability and better adaptation of the new varieties. In some cases —e.g. in Kavkaz and Avrora — the rapid degeneration of the variety is explained by a sudden loss of resistance to powdery mildew. In our trial plots the wheat variety Kavkaz has given a 50—60 q/ha uniform grain yield every year. In the powdery mildew resistant year of 1976 it produced the largest yield (70 q/ha) of the past six years under experimental conditions.

Koltay, Á.: In the case of wheat we cannot speak of a too frequent replacement of varieties. Bezostaya 1, for example has been included in commercial production since 1960. There were undoubtedly new derivates that did not come up to expectations. It cannot be denied that some populative varieties deteriorate at a surprisingly fast rate if varieties of hybrid origin are not regularly selected for the most valuable biotypes.

The new varieties, developed both in Hungary and abroad, which are taken into cultivation are evaluated by the impartial National Agricultural Variety Testing Institute. Permission for propagation and later state qualification is only granted to varieties superior to the control. Experience shows that the potential yielding ability and many other properties of the new qualified varieties really are better than those of the earlier varieties they replace. At present yielding ability is the first requirement, though it is often not coupled with yield reliability, which can only be determined after several years. At farm level, however, they are very particular about this feature, and if experience proves unfavourable the varieties which do not fulfil the requirements are immediately replaced. In the future a more rapid change of variety can be expected in the case of wheat; owing to mechanical and biological mixing at the farms the purity of a variety can be maintained to a limited extent.

Láng, G.: In commercial production the varieties retain their good hereditary properties for many years. As proved by a number of trials the new variety becomes adapted to the local conditions in the course of cultivation, and as a result its yielding ability may even improve. The so-called degeneration can be traced back mostly to a mixing of varieties, or to the improper handling (cleaning, dressing, etc.) of the seed. The most recent Hungarian farm statistics also confirm that after three or four years of reproduction the yield of the variety increases. Thus, in new varieties developed with the recognized procedures the degeneration is not fast enough to demand a rapid replacement of the variety. There are other reasons for the more frequent replacement of varieties, the main one being perhaps that the plant breeding establishments now have a larger capacity than in the past, so the rate at which new varieties are developed has accelerated. Consequently, new varieties superior in some respect to the former ones are produced more rapidly.

Lelley, J.: For the last twenty years the exchange of cultivars has accelerated in all wheat-growing countries. The rapid progress of science and technology following the world war created a situation where a different type of cultivar is required. This is the reason why the old steppe wheats have been replaced by intensive types in Hungary. The exchange of cultivars has recently slowed down again, with a simultaneous increase in the number of cultivars included in field production. The latter is explained by the fact that an up-to-date mechanized wheat production demands a wider range of cultivars.

It is a strange situation in Hungary that the overwhelming majority of the wheat area is sown to wheats of Soviet origin and not to Hungarian cultivars, since the hereditary yielding ability, yield reliability and quality of certain Soviet wheat cultivars are excellently realized under Hungarian conditions. This process is promoted by the fact that as a consequence of mechanization and chemization the cultural practices have become uniform, whereby cultivars developed inneighbouring countries are better able to compete with the Hungarian-bred wheats.

The data of the National Institute for Variety Testing show that this is, indeed, the case with some Soviet, Yugoslav and even Bulgarian wheat cultivars. Thus, in Hungary the old cultivars are replaced by really valuable new ones. The more rapid exchange of cultivars is thus the consequence of increased competition.

It is possible that in the course of continuous production one or another cultivar loses some of its valuable properties, but the discontinuation of hybrid vigour is quite out of the question. By the time a new cultivar is introduced into commercial production, elite seed is supplied by the F_8 to F_{10} generations, when hybrid vigour cannot be found even in traces. If a cultivar shows real signs of deterioration, then mistakes made in the course of maintenance must be responsible. In my opinion, the reason for introducing new cultivars in Hungary is that they really are better rather than that the earlier cultivars have deteriorated.

NAGY, B.: In my opinion varieties are replaced in wheat production for two basic reasons:

a) owing to the sharp competition in the field of productivity increase and variety certification the breeders have neither the time nor the patience to develop varieties which fulfil the requirements, consequently a considerable proportion o f the new new varieties are not stable, particularly genetically, and deteriorate in a short time;

b) the demand for an increased yield average is increasing parallel to the industrialization of production and the increase in input, therefore the farmers seek for supposedly or actually high yielding varieties.

POGÁCSÁS, GY.: The change of variety is a healthy process in wheat production, provided the existing variety is replaced by a new one giving a per ha yield of higher financial value. It is theoretically possible, though never feasible in practice, for the farms to change varieties every two or three years.

For various reasons the change of variety has certainly been too rapid recently. Some Hungarian and foreign varieties were submitted for state certification too early, and certain of their properties became known only when they were already included in commercial production (e.g. the high susceptibility of the variety Avrora to powdery mildew). Without a knowledge of these properties the farms are unable to ensure the right conditions (soil, cultural practices, plant protection) for the variety, and after a year or two of failure or only moderate success they give up growing the variety, although the expected yield could be obtained if optimum conditions were provided.

In some farms, on account of carelessness or financial narrow-mindedness, the necessary seed is obtained for years from wheat intended for consumption (i.e. seed of an inadequate degree of propagation is sown), and the wheat varieties grown from such seed do in fact show the signs of degeneration in the course of evaluation.

(When the varieties Libellula and Bezostaya 1 are grown from seed of good quality and a high degree of propagation they still yeield as much as or, due to improve production technology, even more than 10—15 years ago.)

The potential yielding ability of the new varieties is generally higher than that of older cultivated varieties, or if they have identical yielding ability they are of better quality, or have a higher resistance to disease, or excel in other properties (winter hardiness, adaptability, etc.). This increases the reliability of wheat growing, with the result that the new varieties are welcomed by the producers.

Many professionals state that the present new varieties are less stabilized and constant than the former ones, and consider that an explanation can be found in the methods used for breeding new varieties. At present the development of a new variety takes half to one-third of the time spent on this work earlier.

The selection time is shorter, breeders use chemicals and hormones in breeding, and when the variety is introduced into commercial production too early signs of degeneration may appear after one or two years. These are : plant stands of uneven height, atavistic types of spike which go back to one of the parents, decreased resistance to disease.

To summarise: the new varieties generally possess a higher yielding genetic basis. The degeneration of varieties previously included in commercial production is of minimum extent and can mainly be attributed to incorrect production technology. The breeders should adapt the new varieties to definite site conditions, in which case their premature withdrawal from cultivation could be avoided.

ROMÁNY, P.: There are two reasons for the frequent replacement of varieties. The less important one is the deterioration of certain varieties, the decrease in their disease resistance. The other, more important reason is the appearance of new, more valuable varieties. The wider and more rapid replacement of varieties in the last decades should be regarded positively, as proved by an increase in the wheat yield averages.

ROSTA,; K.: The yielding ability of the wheat varieties included in commercial production is not sufficiently exploited. This is partly due to the high sensitivity and poor adaptability of some varieties to certain cultural conditions. Since the climate of Hungary is of mixed character (Atlantic, Mediterranean, East European and continental), the varieties respond to these extremely varying weather conditions with greater or lesser yield fluctuations. In the course of propagation and continued cultivation more sensitive plants may perish, and the yield potential of the variety may also be modified.

In my opinion the frequent replacement of varieties is due to the appearance of more reliably grown, higher yielding, more disease resistant wheats rather than to the degeneration of the older varieties.

I think that, when changing varieties, it should be taken into consideration that under the varying weather conditions in Hungary only varieties with good adaptability will give reliable, high yields.

SEMJÉN, I.: In the last decades we have witnessed a revolutionary transformation of agriculture, including radical changes in wheat production and wheat varieties.

We did not willingly part with our best known varieties (Bánkúti 1201, Bánkúti 1205), which were outstanding. The quality of the wheats of the Tisza region (Tiszavidéki) was once unparallelled.

A revolutionary change occurred in the early sixties with the introduction of Bezostaya 1 and Bezostaya 4 into commercial production. Their potential yielding ability was amazing. With regard to winter hardiness, hl-weight, gluten and protein content and baking quality they are excellent even today. With their strong stalks they met all the requirements of large-scale production. Owing to their excellent properties they soon excluded the Italian and French varieties (San Pastore, Fortunato, Autonomia, Produttore, Etoile de Choisy) tested simultaneosly. This victory was the victory of quality, though the latter varieties did not reliably yield quantitatively more than Bezostaya 1 either. However, this happened some 10—15 years ago. It may be due to our peculiar respect for traditions or to our slow recovery from our astonishment that we have stagnated. Our breeders have only tried to refine these varieties, or to adapt them to our conditions. They have not attained any substantial yield increase in this way. They have paid attention primarily to quality. In the meantime world demand has shifted towards quantity, which is not surprising, as the present growth rate of the world population calls for ever increasing quantities.

Considering what has been said above, the rapid change of varieties cannot be attributed to the degeneration of the wheat varieties; it is a requirement of practical life. The earlier varieties fulfilled their task under the conditions prevailing at that time but should now be replaced by better ones. Even a more frequent change of variety would not cause any trouble if better and better varieties were always available. It is the joint task of science and practice to determine the right rate of change.

SZALAI, L.: The quick change of varieties in wheat production is not, in my opinion, due to the degeneration of the wheat varieties introduced. The most obvious case is that of Bezostaya, a wheat variety much critized for its deterioration in quality in Hungary, though in stands which have been kept pure this cannot be demonstrated even now. On the other hand, many other poorer quality wheats were grown parallel to the dominant Bezostaya 1, and the mixing of seed deprived the producers of the expected quality.

The relatively frequent replacement of varieties is related primarily to economic questions. The current state purchase prices encourage the growing of higher yielding varieties. Larger yields are not, however, coupled with better quality.

SZALAY, D.: The rapid development of wheat growing (with more intensive cultural practices and new varieties), and the doubling of the national yield average in 10 years (from 21.6 q/ha in 1966 to 38.8 q/ha by 1976) modified the demands made on the varieties and certain characters indispensable. Ten years ago a 100 q/ha yield seemed unbelievable, while this year 80—100 q/ha averages have been obtained from the best wheat fields of some farms. Such a yield level calls for a new type of variety.

Under the given conditions the development of optimum yielding varieties, possessing all the desired characters, requires many years of continuous work. In this process the improvement of one or another character may justify a change of variety, although it is known even when a variety is accepted that some of tis properties still needed to be improved. During the last two decades many farms have increased the sowing area of the variety Sava owing to its favourable properties and outstanding potential yielding ability, although it is generally known to be of fodder wheat quality and to have poor winter hardiness compared to the Soviet and Hungarian varieties grown.

Most of the currently cultivated wheat varieties are inferior to the ideal type. It is thus favourable for the breeders if a larger number of varieties are included in commercial production. The large variety assortment generally promotes development, since the value of a cultivated variety is ultimately ascertained by its performance in practice. The rapid change of varieties may, however, have an adverse effect. (In the fifties the three breeders working at Bánkút regarded the maintenance breeding of the variety Bánkúti 1201 as their main task.)

It is not the disappearance of hybrid vigour that leads to the rapid replacement of a variety. At best a line is accepted 8—10 years after crossing. If in the 8th hybrid generation the total stand of a prospective variety produces a fairly large yield this can generally be maintained by starting an appropriate number of sub-lines and selecting them after a careful evaluation. The rapid development of wheat production and the demands of the farmers urge the introduction of new varieties into commercial production. The widening of the breeding possibilities ensures that wheat types better than their predecessors will be produced almost in series. With the appearance of varieties whose characters are optimum for cultivation the change of varieties will slow down.

SZÁNIEL, I.: The frequent change of varieties is due to several reasons, such as the higher yielding ability of the new varieties, decreased resistance to possible new or sub-races of fungi appearing under ecological conditions different to those at the breeding site of the variety or in different years, and so on.

TULCZ, I.: In my experience wheat varieties with a solid genetic basis do not deteriorate and are not replaced in a short time. Apart from Bezostaya 1, Fertődi 293 and Libellula, a so-called fodder wheat, may be mentioned. All three varieties have retained the potential yielding ability exhibited when they were introduced into commercial production.

On the other hand, the highly promising varieties Kavkaz and Avrora lost much of their yielding ability within a few years.

Jubileinaja 50, the third Soviet variety introduced with Kavkaz and Avrora has occupied a larger area every year in our county, and does not show any sign of degeneration as yet.

To sum up: in my opinion the rapid change of variety is due mainly to the development of high yielding varieties within a short time by Hungarian breeders, parallel to those recently introduced from abroad.

It was thus possible to replace the above mentioned varieties, which had been cultivated for some time, by higher yielding ones.

The withdrawal from cultivation of varieties showing signs of degeneration may also take place within a short time.

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PÁL, GY.: **The weather in Hungary may be continental, oceanic or Mediterranean both in winter and summer according to the prevailing climatic influences. Considering the large volume of pasta imported by Hungary, do you think that the production of durum wheats, which are grown in southern areas, in the Mediterranean region, can be expected on large areas in Hungary in the near future?**

BALLA, L.: Durum wheats can only be expected to spread in Hungary (including the southern parts of the country) after the development of new early, winter hardy, high yielding, resistant varieties.

BEKE, F.: There is a need to grow durum wheats. Winter durum wheats are just as unreliable as spring ones with regard to yield. This problem has not been solved in the Soviet Union either, in spite of many decades of breeding work. The spring wheats are more reliably grown, but only in special farms with strict technological discipline.

BELEA, A.: Spring durum wheats grown in the Mediterranean region, and the winter durum varieties included in the commercial production of certain countries are not suitable for growing in Hungary owing to their late ripening and poor winter hardiness. As crossing partners, on the other hand, they can be successfully used. Considering the demands of the pasta industry it would certainly be justified and necessary to encourage the breeding of late, winter hardy durum wheat s in Hungary.

BOCZ, E.: Many years of experimental data are required to determine the effect of Hungary's weather on the quality of the yield. In the final analysis it is economic calculations that will decide whether it is possible or worthwhile to satisfy Hungary's requirements from domestic production.

CSONTOS, M.: The sowing area of durum wheat will hardly grow simply because of the pasta imports, but only through the influence of other economic regulators.

ERDEI, P.: Beyond the theoretical considerations, under the meteorological conditions which have held for the last 4—5 years the production of certain winter durum forms in the southern part of Hungary has been successful. Some of them have good and others less good winter hardiness. Unfortunately, not a single durum wheat attains the level of aestivum wheats of Hungarian and Soviet origin as regards winter hardiness. Yet, some of them are equal in this respect to the Italian variety Libellula, which has been successfully grown in the southern and central part of the country during the last ten years. At present its distribution will primarily be determined by economic factors rather than by the cultivation conditions. Apart from this, the introduction of durum wheats into commercial production is motivated by many subjective and objective elements.

KISS, Á.: Under the extreme weather conditions of Hungary durum wheats with poor winter hardiness often show lower yielding ability than the aestivum types. If the requirements of the pasta industry make it necessary, and the manufacturers compensate the producers for the losses resulting from the lower yield, then durum wheats can certainly be expected to spread in the southern part of Hungary. Under favourable weather conditions the new semidwarf durum wheat varieties come close in yielding ability to the intensive bread wheats.

KOLTAY, Á.: The hard-grained Triticum durum is suitable specifically for the production of compressed dry pasta without additives. Such raw material is not at present required in the Hungarian pasta industry. From the flours of the commercially produced varieties excellent quality pasta can be manufactured by adding eggs, which satisfy the demands of the domestic consumers in every respect, and can also be exported without difficulty.

Owing to the fluctuations between low and high yields the production of durum wheats would not be economical for the farms with the present price policy.

If durum wheats were actually to be grown, mixing must be prevented by all possible means; this could only be ensured by the separate handling and processing of the products of isolated growing areas.

In my opinion, the production of durum wheats on large areas in Hungary cannot be expected in the near future.

LÁNG, G.: In order to answer this question it is necessary to know whether the breeders will succeed in developing durum wheats which are not much inferior to the aestivum type as regards yielding ability and yield reliability. Under the climatic conditions in Hungary this durum wheat will have to be a winter variety. It is a well known fact that the winter types have not yet been sufficiently tested for winter hardiness under Hungarian conditions. With a view to satisfying the raw material requirements of the developing pasta industry in Hungary from domestic production, it would be practicable to give more encouragement to the breeding and introduction of durum wheats. However autarchic views must not be given precedence in evaluating the new durum wheat varieties; in judging whether production is economical the price ratios on the world market must be taken into consideration.

LELLEY, J.: It would be desirable to satisfy the raw material demand of the pasta industry in Hungary. There have been repeated attempts to breed durum wheats, but as in the production of spring wheat, durum type wheats have failed to spread in Hungary. I think it should be possible, by means of sustained breeding efforts, to produce a semi-dwarf, disease resistant, winter hardy durum winter wheat, which could compete in yielding ability with the aestivum wheats even in Hungary. However, the winter hardiness of the durum wheats known at present will probably not be sufficient under Hungarian conditions. It is therefore questionable whether or not durum wheat production on larger areas should be started in the near future. If the breeders succeed in developing durum winter wheat fulfilling the above requirements, there seems to be no objection to a limited extent of durum production. Provision should be made, however, to isolate it from the aestivum wheats, lest it should endanger the quality of the Hungarian bread-wheats. In a regional distribution of this kind, durum wheats would have to be grown primarily in the southern parts of the country. This would not, however, be advantageous because the production areas of quality bread-wheats in Hungary also fall within this zone.

Breeding durum wheats is desirable in Hungary as elsewhere, if only because they are expected to play an increasing role in the future owing to their high protein contents. However, as long as their suitability for production in Hungary is not unambiguously established, and the areas of production are not marked out, their production is not recommended.

NAGY, B.: In my opinion durum wheats cannot be expected to spread until high yielding hybrids are available, since the present system of incentives is not sufficient to force the producers to grow this type of wheat, which, while good in quality, falls behind the soft wheats as regards yield reliability and yielding ability.

POGÁCSÁS, GY.: I have not grown hard-grained durum wheats, nor have I set up farm-scale trials with them, so my opinion can only be based on literary data.

PLETSER, J.: It is a good omen for the acclimatization of durum wheats in Hungary that the systematic breeding carried out during the last decade and a half has produced durum winter forms whose increased winter hardiness enables them to be grown in regions farther north than earlier. Today durum wheats are sucessfully grown on the Po plain and on the hills of Bologna, as well as in Sicily. The growing area of durum wheats has shifted northwards in the Soviet Union as well. In comparative small-plot trials the yield of prospective varieties produced in Hungary has come close to the yield level of aestivum wheats. The mild winters of the last years do not, however, mean that the climatic conditions in Hungary are suitable for the production of durum wheats. Over an average of fifty years, ten severe winter days (with a minimum air temperature of —10°C or below) occur annually even in the southern parts of Hungary. The frequency of daily minimum temperatures at Szeged is shown in Table 1.

According to the frequency percentages a few days with a minimum temperature of —20°C can be reckoned with every three years. Temperatures between —10 and —15°C can be expected every year on 3—4 days in each winter month, giving a total of 10 occasions. In extremely cold winters the air temperature may drop to —30°C even in the southern part of Hungary. On 24th January 1942, —29.1°C was measured at Szeged.

Before durum wheat can be introduced its winter hardiness must be tested and climatic probabilities must be used to decide whether production would be an economic proposition.

Table 1

*Percentage frequency of daily temperature minima. Szeged, 1901—50. (Kakas 1967)**

	XII.	I.	II.
$\leq -20°C$	1	1	1
−15 — −20°C	2	3	3
−10 — −15°C	9	14	10

* KAKAS, J. (ed.) (1967): Magyarország éghajlati atlasza II. Adattár (Climatic map of Hungary II. Collection of data). Akadémiai Kiadó, Budapest, 41—82, 125—160

ROMÁNY, P.: In order to produce better quality products the pasta industry requires a certain quantity of flour obtained from durum wheat.

Durum wheat has lower yielding ability than other types of wheat. Economic calculations should be made on the purchase prices the pasta industry can afford to pay for wheats of this quality, to determine whether these prices would compensate the farms for the loss resulting from the lower yield. Breeders ought to make every effort to increase the yielding ability of durum wheats. The question of whether an increase in the production area of durum wheats in Hungary is economical or not can only be decided by complex analyses.

ROSTA, K.: With a view to satisfying the rquirements of the pasta industry and the possible export demands, I consider the production of durum wheats on limited areas in the southern parts of Transdanuba and the Great Plain reasonable.

In order to avoid frost damage caused by occasional cold, snowless winters, it would be better to grow durum spring wheats, which produce somewhat lower yields, but which can be grown more reliably, rather than durum winter wheats.

SZALAY, D.: After several decades of breeding work at Odessa and Krasnodar there is still no winter form with adequate winter hardiness and yielding ability in the morphological range of hard-grained wheats *(T. durum)*. In the Carpathian basin L. Veneny tried, from the 1920's onward, to produce *T. durum* varieties but without success. Wheats sown in spring give substantially lower yields in Hungary than those sown in winter, so spring durum wheats are not competitive under Hungarian conditions. The number of varieties belonging to this species is only a fraction of those found in *T. aestivum*, and intensive types are missing almost completely. On the above grounds it is very difficult to produce a durum wheat fit for Hungarian conditions. There is little likelihood of successful breeding within the foreseeable future even if considerable investments are made.

I do not think that *T. durum* will be introduced into commercial production in Hungary for some years to come in spite of the fact that its world market price is considerably higher than that of common wheat.

SZÁNIEL, I.: I am sure that durum wheat can be grown on a larger area even under Hungarian weather conditions. It must be added, however, that there are a number of objective and subjective conditions for this. The most important of them is to obtain a sufficiently high yielding winter hardy variety, and to make durum wheat economically acceptable. Separate storage, milling, the manufacturing of pasta without eggs, the creation of possible export markets for durum wheat, the export of pasta, etc. are all problems that remain to be solved. The sites most suitable for durum wheat production should be found and made known to the producers, and pasta manufactured without eggs must be popularised with the consumers.

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PÁL, GY.: **Hungary is placed fifth among the countries growing wheat on an area larger than 1 million ha; its territory falls within the quality wheat producing zone. Considering the high world market demand even for non-quality wheats, and the fact that the population of Hungary still satisfies a large proportion of its protein requirements from wheat, and also taking into account the extra price per q paid for quality, should preference be given to the breeding and, even more, to the production of quality or non-quality wheat?**

BALLA, L.: Hungary is a country traditionally producing and consuming good quality wheats. The Hungarian milling and baking technology, the quality criteria, and last but not least the demands of the consumers require that good quality wheats be grown. On a smaller area poorer quality wheat might be grown temporarily for animal feeding purposes, but this is no longer of much importance, as the variety Martonvásári 4 is equal to the fodder wheats as regards yielding ability and earliness, and its winter hardiness and quality are unobjectionable.

BEKE, F.: In my opinion cereals will be the most important economic weapon (similar to oil) in the period ahead. It is quantity rather than quality that will be of decisive importance. The question of food, particularly of protein, will be complemented by a search for other foods or plants, and other technologies. It is a lucky occurrence to find yielding ability coupled with high quality, as experience shows that the correlations are usually negative, though this is not inevitable.

BELEA, A.: Breeding wheat for quality has great traditions in Hungary. The available Hungarian wheat gene stock (Bánkúti, Fertődi, Bánáti, etc.), which is an important quality gene source all over the world, should be increasingly utilized for crossing. The producers should be given a premium for quality to make them interested in growing quality wheat. Our exports can also only be increased with quality wheats.

BÓCZ, E.: Farms have recently preferred growing higher yielding varieties which do not meet the traditional quality requirements.

In my opinion, with a view to the reliability of production it would be better not to fix the ratio of wheat varieties as yet. At present better quality wheats are grown in quite a large proportion, and they are sufficient to improve the quality of bread at home and to satisfy the current export demands as well. To a certain extent, farms are incited to grow better quality varieties even by the current prices. If a farm decides to grow poorer quality wheats, it certainly has a good reason for doing so, thus the decision should be accepted.

CSONTOS, M.: Wheat breeding in Hungary should concentrate on quality. At the same time, about one-third of the wheat area of Hungary should be made available for the production of non-quality foreign wheat varieties. In this way the domestic demand for quality can be satisfied, while the production of varieties grown for export, and known to the buyers, can be adjusted to world market demands.

ERDEI, P.: As long as wheats are evaluated in Hungary by commercial characters (hl-weight, hardness, thousand-grain-weight, etc.) rather than on the basis of the quantity and quality of protein, production will give preference, for economic reasons, to "quantity" wheats.

The production of high yielding but poor quality wheats cannot be the purpose of breeding in Hungary. On the contrary, good quality and grain composition coupled with high yielding ability must be aimed at.

KISS, Á.: What is quality wheat? In Hungary good quality white bread is made from the flour of wheats with a high gluten content. Is this bread of high nutritive value? While certainly tasty, it cannot be considered nourishing. Its nutritive value cannot be compared with that of bread made of rye-flour, which contains 40—60% more lysine. Is any attention paid to the biological value, the vitamin B_1 content of bread? Rye, and particularly the stabilized wheat-rye hybrid ensure, by means of their higher protein content and increased amylase activity, bread with higher lysine, tryptophane and vitamin B_1 contents.

By means of proper health propaganda this also should be included in the concept of quality bread; the quality of the tasty white bread ought to be improved by adding rye or triticale flour to the basic material in order to increase the nutritive value of this highly important foodstuff, and, through its natural vitamin B_1 content, to provide a highly efficient medicine against cardiac infarction.

Thus, while giving preference to the production of quality wheats, arrangements should be made to ensure a certain proportion of flour with higher protein, tryptophane, lysine and, last but not least, vitamin B_1 contents, and, if necessary, the food industry should be encouraged to produce healthier bread with a higher nutritive value. This is imperative if the healthier nutrition of the population is to be achieved.

KOLTAY, Á.: Everything should be done to ensure good quality. We are a bread-eating nation, and bread and other farinaceous products will remain important foodstuffs in Hungary for a long time. The demands made by the population of Hungary as regards the quality of bread and of farinaceous products in general (milk-bread, strufel, granulated dry pastry, noodles for soup, etc.) is well known. This demand should be satisfied as fully as possible.

Wheat is primarily a raw material for the milling and baking industry, therefore its utilisation value (quality) is determined by the demands of these industries. The wheat required for the milling and baking industries should be red-brown, hard, full, fine-coated, with a glassy fracture, 40—50 g thousand-grain-weight, the highest possible hl-weight, and above all a high, good quality gluten content. All these properties, but particularly the quantity and quality of gluten, are more or less steadily transmitted traits, though they are influenced by many other factors. Among the objective of wheat breeding, emphasis must be laid on quality, as well as on other characteristics wich determine the production value.

There have been examples in the history of Hungarian wheat breeding of good quality and up-to-date yielding ability being not necessarily opposing features.

The effect of climatic factors on quality is a generally known fact. Temperature and light conditions between heading, ripening and harvesting are determinants in the case of wheat. The quality of the flour is more independent of the extremes of climate in really high quality wheats, though the differences between the years are invariable great.

The breeders have already produced high yielding varieties of intensive character and unobjectionable baking quality. The new selections are excellent in this respect, and endeavours should be made in the future to grow quality wheats on the entire sowing area, if possible.

The quality of the wheat is decisively influenced by the time of harvest. Experience shows that the same wheat variety grown at the same site in the same year may be of good, medium or quite poor quality when harvested at different times. It also holds true that in dry weather, optimum for harvesting, the varieties keep their hereditary good quality even when cut at the stage of dead ripeness.

Kurucz, Gy.: The wheat variety assortment in Hungary should include both quality (higher protein content) and non-quality wheats. The question of whether it is pr acticable to breed wheat for quality in Hungary should be decided taking into consideration the available breeding material and the intellectual and financial resources of the country. The introduction of foreign quality wheats must not be left out of consideration. In my opinion, the improvement of non-quality wheats is the main breeding objective in Hungary.

On quite large areas of Hungary, especially along the river Tisza and in the southern part of the country, quality wheats can be efficiently grown. The type of wheat grown by a farm is primarily a function of profitability. Prices, i.e. profitability conditions, are centrally regulated. The ratio of quality to non-quality wheats to be grown is decided by the state on the basis of domestic requirements and export possibilities.

Láng, G.: The more properties the plant breeder has to consider in developing a new variety, the higher the diversity of the material with which he must work and the more difficult the task of selection. This is especially true of properties which are in negative correlation to one another. The negative correlation between the quantity and quality of yield is not, however, unalterable. There would be no point in increasing the production potential of a wheat variety while leaving the quality completely out of consideration. The break-through mentioned in connection with the negative correlation provides an opportunity in this direction. At present quality is generally understood as being the suitability of the flour for baking bread and similar products. As we saw in connection with the previous question, the quality standards for dry pasta production are different. Finally, in countries where the main protein source is derived from cereals, the quantity and biological value of the protein are the most decisive indices of quality. This point of view is also the most important for fodder wheats. Under the present conditions in Hungary it would hardly be economical to consider only the quality or only the quantity. A sound compromise ensures the economic optimum for both domestic consumption and exports.

Lelley, J.: The cassical interpretation of baking quality shows a changing tendency all over the world. The causes are:

a) In the developed industrial countries of Western Europe, which earlier willingly bought high quality wheats grown in the region of the river Tisza to improve the quality of their flours, the efficient work of their breeders has resulted in their growing wheat cultivars which mostly meet their demands for baking quality.

b) Knowing the bakery products consumed in these countries, and considering the increasing emphasis laid on "calory-conscious" nutrition one cannot be surprised that the type of bread usual in Hungary is not sought after in these countries, and they are used to products for which classical baking quality is not a necessary condition.

c) In the same countries, due to the perfection of milling and baking technologies uniform quality is preferred to excellent quality.

d) From the point of view of food supplied to backward and developing countries, the total protein content of the wheat is much more important than its baking quality.

This changed view will remain prevalent in the future. I am far from claiming that breeders should neglect the baking quality, but its fetishization at the expense of yielding ability would be a great mistake.

The inverse correlation between yielding ability and quality only causes difficulties if breeding is nearing extreme yielding ability. There are exceptions even in this case, e.g. Bezostaya 1, or Jubileinaya 50. Good quality must thus be kept in view in the future as well, but the further increase in yielding ability requires certain concessions, though only to an extent which will not damage the reputation of Hungarian wheat. In this connection I consider that quality wheat production should be regionalised.

I should like to call attention to an ever increasing demand in connection with the total protein content of wheat. The protein content of the aestivum wheats grown at present is 12—13%. Considering that the population covers its plant protein requirement almost exclusively from wheat, it would be very useful to increase the total protein contents of wheats in Hungary. By well-considered systematic breeding major results could be attained without sacrificing the baking quality.

Unfortunately, breeding for improved essential amino acid composition has failed to give concrete results so far, although this could be of even greater importance from the point of view of the national food supply. I am sure that the solution of this problem is only a matter of time. I suggest, therefore, that greater attention must be paid to increasing the total protein content and improving the amino acid composition, without neglecting the baking quality.

NAGY, B.: My answer to question 4 practically covered question 5 too. In my opinion, since the southern wheat varieties have avoided a natural selection for winter hardiness during the past mild winters, they can only be grown with the risk of a substantial loss occurring if there should be a continental winter. Their share in cereal production must not therefore go beyond the limits of a calculated risk. At the same time, taking care not to discourage the farmers, the production of these varieties is unavoidable, particularly for animal nutrition purposes, due to their high yielding ability.

POGÁCSÁS, GY.: The price of eating wheats in Hungary is uniformly 295 Ft/q irrespective of the variety. For wheat producers the quality requirements are therefore determined by this price. We prefer those wheat varieties which give the highest yields per ha.

Quality wheat would only be worth producing for export purposes, provided the wheat producing farm were given a premium of at least 15—20%. At present this is not possible in Hungary, and with the current economic regulators there is not much likelihood of it becoming possible during our lifetime. It is superfluous to deal with quality wheat production.

ROMÁNY, P.: Owing to the present purchasing system (criteria of quality on receipt, purchase price) priority is given by the producers to an increase in quantity because of its higher profitability (e.g. Libellula). The breeders, on the other hand, mostly endeavour — quite rightly — to produce high quality wheat varieties. The recently certified Hungarian wheat varieties are good quality wheats for human consumption. By increasing the yielding ability of high quality wheats, as well as by using stricter criteria of quality on receipt, the farms could be made to give priority to high quality wheat production.

ROSTA, K.: The climatic conditions in Hungary, which are favourable for growing quality wheats, should — in my opinion — be utilized to the highest possible extent. Today there are good baking quality wheats (including Hungarian varieties) which give reliable, high yields. Beside quality wheats I think it reasonable to produce a definite proportion of reliably grown, yielding, high so-called soft wheat varieties.

SEMJÉN, I.: There are an increasing number of varieties which, besides having satisfactory yielding ability, also meet the quality demands raised by the world market. The production and present state of development of oil crops and legumes provides a greater possibility of covering the protein requirements of the population than the production of wheat.

Besides taking quality requirements into consideration, breeding should be aimed at increasing the quantity and at improving resistance to fungal diseases. Increased quality is not, however, in proportion with the value of the quantity produced. When examining the quality in terms of nutritive value we find that in a larger volume more useful nutrients are available over the same area.

Baking quality (the intensity with which the dough rises, etc.) is a different question, which could be greatly improved by quality work in the baking industry, even if this required extra financial input. This would certainly be cheaper than putting up with smaller yields in favour of higher baking quality.

In our experience the varieties suitable for large-scale production are those which are resistant to various fungal infections (Libellula, Jubileinaya, Sava, Zlatna dolina, etc.). They generally ripen by the beginning of the rainy summer period, so they can be harvested under fairly dry conditions and their quality can be preserved well. There are innumerable examples of the post-harvest quality of early wheats being superior to that of the late varieties. They do not become leached or soaked, they can be harvested easily and at low cost, they need drying only exceptionally, and are easy to store. Under Hungarian conditions the grains of late quality wheats often shrivel at ripening.

According to our present knowledge of wheat varieties, early, high yielding varieties resistant to fungi should be widely grown.

SZALAI, L.: Wheats of very high quality can undoubtedly be grown in Hungary. Considering that good quality wheat varieties also have high yielding ability, I think that the production of high yielding, good quality wheats should be the primary aim. At the same time, it is reasonable to develop and produce special fodder wheat varieties for feeding purposes, but a sharp distinction must be made between fodder and eating wheats, since the demands made on the quality of eating wheats are quite different from what is expected of fodder wheats. For example, fodder wheats ought to be evaluated for their feeding value, instead of being placed in the fodder wheat category simply because their baking quality is inferior to what is rightly demanded from an eating wheat. Good fodder wheat is subject to just as stringent quality standards as eating wheat. Accordingly, it is reasonable to pay as much attention to the production and marketing of fodder wheats as to those of eating wheats, but the two cannot be interchanged under any circumstances.

Industries utilizing wheat or flour are in the process of rapid development all over the world; they are characterized by a high degree of production concentration, mechanization, and in many places automation. Technical progress of this kind is inevitably associated with uniformity of quality. Uniform, good quality flour ensures a uniform good quality end-product. Today not only are machines suitable for replacing physical work used in baking technology, but also those which improve the quality, though otherwise of no economic use. However, a precondition for the operation of such machines is the adequate quality of the basic material. Flours of poor baking quality cannot be transformed into ones of adequate quality by any technological procedure or chemical treatment. That is why quality wheats should be given preference in wheat production.

SZALAY, D.: At present the efficiency of wheat production in a given farm is decisively determined by quantitative indices. The premium paid for quality is very low and is not always realized (during harvesting there is neither time nor apparatus for suitable quality control).

Further steps should be taken to make the farms interested in growing varieties with good quality flour. In Hungary the conditions, the traditions and the present demand all justify the production of quality wheats. The consumption of bread and pasta is relatively high in Hungary. The population lays great emphasis on the quality of bread, farinaceous products and flour. Thus, the maintenance or possible improvement of the baking quality of wheat should be included in breeding objectives. This is also justified by the export possibilities. Excellent quality wheats can be sold with more certainty and at a higher price.

In fodder wheats the gluten quality can be totally neglected. The value of wheat varieties produced for feeding purposes is determined, besides the crop volume, by the amount and biological value of the proteins. The improvement of these properties cannot be neglected in wheat varieties produced for eating purposes either, but in these varieties good gluten quality is a primary requirement.

SZÁNIEL, I.: First of all, it is not quite clear what quality means at present. Above all, the baking industry demands uniform baking quality. Steady B_1 quality flour is preferable to fluctuating A_1—A_2—B_1 quality. Wheats and flours with A baking quality are used as quality improvers, while the C wheats are of fodder quality. Protein content is not yet an economically recognised quality factor.

The question arises, which of these major quality factors should be preferred. The best way is probably to consider them all important, as all of them are needed. In breeding, the development of varieties with excellent (A) baking quality and higher protein content and the development of fodder wheats should have priority. The production of a mixture with uniform quality is a question of storage and milling.

But in this case too the problems of separate storage and economic acceptance arise both with respect to baking quality and protein content.

SZÉKESSY-HERMANN, V.: The territory of Hungary falls within the quality wheat zone, thus irrespective of the world market demand for non-quality wheats I feel the accent should be placed on growing quality wheats in the near future for the reasons outlined below.

There are two main requirements of correct nutrition, one of which is quantitative, that is, to satisfy the calory requirement, and the other qualitative, that is, to supply indispensable compounds such as essential amino acids, vitamins and other accessory substances.

Today the nutrition of people in backward and developing countries is undoubtedly characterized by quantitative (calorific) deficiencies. Nevertheless, the worldwide development of agriculture, the process of mechanization, the techniques of soil amelioration and the new plant varieties tolerant to unfavourable climatic conditions, together with the activities of various world organizations and the social progress of the peoples concerned, all suggest that apart from in regions affected by catastrophes the quantitative component of nutrition is likely to be solved. But in any case, since Hungary is a small country it possesses only a low potential in this respect.

The other serious problem to be solved is the quality of nutrition. The deterioration of food quality due to the preference given to large yields threatens unpredictable consequences. More and more statistical data call attention to the fact that hardly registered qualitative changes in our foodstuffs may cause a reduction in the intellectual capacities rather than a physical weakening.

If we consider only the protein requirement it cannot be denied that this can be covered by foodstuffs containing biologically less valuable proteins, but in that case a substantially larger quantity of food would have to be consumed. To mention some extreme examples: the daily 0.7—1.0 g/kg body weight protein requirement for adults recommended by WHO is fully covered by the consumption of 0.5 kg meat, while even 1 kg of wheat would hardly be sufficient. For the organism neither large surpluses of amino acids useless in building its own proteins, nor a permanent excess of nutrients supplying calories (carbohydrate and fat) are a matter of indifference. The former overburdens the organism owing to the synthesis and excretion of nitrogen-containing metabolic end-products, while the latter is the source of pathological changes, particularly in the heart and blood-vessels, associated with obesity. It is worth considering a remark in a recently published biochemical text-book, namely, that in the developed countries the nutritional habits are a source of concern, because while the rapid progress of technology and industrialization is making hard physical work a thing of the past, people still eat and drink as if they were doing hard physical work.

The combination of egg and potato proteins is a notworthy example of a favourable combination of proteins of animal and vegetable origin. The biological value of proteins is usually referred to full egg protein, which is taken as 100. Egg and potato proteins in a ratio of 1 : 2 provide a favourable amino acid composition with a biological value of 135. Naturally, this is only of experimental interest, as the protein content of potato is low, and if we were to cover our protein requirements in this way, we would have to consume one and a half eggs and about one and a half kg potato a day.

In most developed countries, besides foodstuffs of animal origin, wheat is the main source of protein for humans and is consumed partly as bread and partly as pasta or pastry. The aim of producing quality wheats should be to ensure that the proteins of wheat provide not only the desired baking quality but also optimum complimentation of the biological value of animal proteins.

TOMPA, GY.: As I see it, an unambiguously concrete answer can hardly be given to this question. The question itself raises the fact that owing to the geographical position of Hungary, high baking quality wheats can be grown on almost the entire wheat area of the country. In my opinion this possibility, which is given to comparatively few countries, must be exploited at all cost, and quality wheat production must not be abandoned on a considerable part of the wheat area of Hungary.

On the other hand, according to the experience obtained so far, there are substantial yield differences between soft and hard wheats in favour of the former, which are able to produce an average yield surplus of 10—15% compared to the latter. In addition, the producing farms are still judged — both financially and morally — on the basis of the absolute volume of yield.

Neither the differences in the state purchase prices for soft- and hard-grained wheats, nor the quality premiums give any special advantage to the producers, owing to the yield surpluses of non-quality wheats. The question should be raised, however, of whether the wheat quality standards currently in use should not be revised when the long-planned reconstruction of Hungary's baking industry becomes a reality. In other words, whether it will be necessary to keep up the area of what is now regarded as quality wheat if the same bakery product can be obtained from a lower quality variety with much higher yielding ability.

Besides its utilization for human purposes the role of wheat as fodder as of growing importance, since its production costs are substantially lower than those, for example, of maize, and being a much earlier crop than maize its utilization may accelerate production in certain livestock branches. The proportion of the area sown to soft or fodder wheat is therefore determined now and in the future by the development objectives of livestock breeding as well.

Last but not least, wheat is an important export commodity for Hungary and this will be increasingly true in the future. In countries where the level of wheat production is sufficiently high, but is attained mostly by the production of soft wheats, there will be a demand for quality wheats from Hungary and elsewhere in order to ensure the required quality by means of the proper ratio of mixing. But it is impossible to ignore the fact that for a very large proportion of the world population even the basic food supply is not ensured, therefore the importance of wheat as a staple food continues to increase.

Hungary has made great progress towards the final aim of wheat breeding: to develop and introduce into commercial production varieties in which high yielding ability is coupled with permanent high quality. The latest Mv varieties and the GK varieties have proved that the joint improvement of quantity and quality is no Utopian demand.

TULCZ, I.: It is obviously quality wheat that should be given preference in the course of breeding, as this is what will make us competitive on the world market in the long run, not to mention the fact that domestic consumption also calls for quality wheat.

The current price conditions do not encourage farms to grow quality wheat. There is a price difference of only 4—5%. The high yielding varieties found among the fodder wheats produce much higher yields than the eating varieties so the farms are not financially interested in growing quality wheat. Another important point is that while livestock farms receive a share of the export premius, in the case of crop production, including wheat, the producing farms are not made financially interested in export activities.

The moral appreciation of higher yields cannot be neglected, irrespective of whether the results have been attained with quality or non-quality wheat.

The quality wheat varieties recently produced at Martonvásár give nearly as much yield as the highest yielding non-quality wheats. Provided these varieties continue to come up to expectations, the question of whether to grow quality or non-quality wheat will be solved. It is obvious that if nearly identical yield volumes can be obtained from the two types of wheat the production of quality wheats will be justified, since the selling price will not come as a shock to the producer.

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PÁL, GY.: **Winter hardiness is a hereditary feature of the variety; owing to its complexity its transmission is complicated and its realization is greatly influenced by environmental factors and the plant's preparation for the winter. Do you think that the wheat varieties introduced from southern countries, which have been grown on large areas in Hungary for several years are sufficiently selected for winter hardiness, sufficiently well prepared for the winter and sufficiently adapted to the environmental factors to be safely grown even in the occasional continental winters?**

BALLA, L.: Wheat varieties of southern origin, with little or no winter hardiness, which are certified and grown on a small area (10—11% of the total wheat area) in Hungary have not become winter hardy and their production is risky. This is not a question of selection or adaptation because fresh seed is imported every year. These varieties may be destroyed by frost even in an average winter.

BEKE, F.: The winter hardiness of wheats of southern origin is not reliable under Hungarian conditions. It is not probable that a few years of cultivation and reproduction will produce essential genetic changes, i.e. adaptation. (The sowing area of San Pastore, which was 200,000 cad.yoke (115,100 ha) in 1962 has been reduced to 70,000 cad.yoke (40,285 ha).) The mild winters of the last few years were Mediterranean winters, but will we wait until a different type of winter comes before we realise the danger again? This is a dangerous point of view!

BELEA, A.: The earlier imported Italian (Fortunato, R16, San Pastore, etc.) and French (Maddalena, Etoile de Choisy) varieties are known to have been replaced in a relatively short time owing to their poor frost resistance and winter hardiness, except for a few Italian (Libellula), French (Etoile de Choisy) and recently Yugoslav (Sava) varieties grown in the southern part of Hungary with a reliability of 50—70%. The mild winters of the past few years have promoted the spreading of these varieties in Hungary. An occasional hard winter, however, will certainly reduce their sowing area. They are not expected to spread further in the near future, since Hungarian plant breeders are endeavouring to replace varieties adapted to local conditions by international ones independent of edaphonic conditions and suitable for growing anywhere in the world.

BOCZ, E.: The farms are rather reluctant to grow high yielding varieties of southern origin on larger areas, especially in the central and northern parts of Hungary. There is certainly a danger of more sensitive varieties perishing in occasional extremely cold winters. The winters have lately been very mild. The next severe winter will force the farms to determine the proper ratio of varieties. Until then it is up to Martonvásár to determine the degree of winter hardiness in the new varieties and to inform the farms of their findings. For the time being it is only on farms in the southern part of Hungary that the production of less frost resistant varieties on larger areas has begun.

CSONTOS, M.: The wheat varieties introduced into Hungary from southern countries, particularly the Italian variety Libellula, have generally become acclimatized to the weather conditions of the country. It is probable that of the three factors mentioned in the question selection for winter hardiness is the decisive one.

ERDEI, P.: Winter hardiness is a hereditary character of wheat, and as such, is of a determinative nature. The selective effect of the ecological conditions, better preparation for the winter, and the adaptability of the variety also play a part in increasing the winter hardiness, but these factors only make their effect felt within certain limits. It is obvious, that of the wheat varieties originating from southern countries only those whose hereditary winter hardiness and adaptability are better than the average have been retained in commercial production.

This is why it has become possible to grow a number of Italian and French varieties successfully for some time in southern regions of Hungary. In order to decide whether southern wheats can be safely grown in Hungary one must know the variety in question and the actual growing site.

KISS, Á.: Winter hardiness is a complex hereditary character. Presumably the winter hardiness of wheat varieties introduced from southern countries and cultivated for several years in Hungary has been improved by slection and become to some extent adapted to Hungarian conditions. It would be a bold statement to say that these varieties can be safely grown even under extremely cold weather conditions. In Hungary severe frost damage may be expected every ten years or so; therefore, it is only in the southern part of the country that these abundantly yielding varieties of southern origin can be safely grown; high yields over nine years will thus compensate for a possible one-year failure of the wheat crop.

KOLTAY, Á.: The milder than average, Mediterranean type winters of recent years have really satisfied the requirements of varieties of southern and western origin. Moreover, in the last few years even Mexican wheat varieties of subtropical origin have suffered no damage during the winter. We must not, however, forget that in the Carpathian basin very cold, continental, dry, snowless winters may also occur, when frost damage to varieties with insufficient winter hardiness has to be expected. The last severe winter was in 1962—63, when, apart from those grown on the southernmost wheat areas of Hungary, the southern and western varieties suffered serious frost damage. A similar cold winter is very likely to occur in the near future. Under Hungarian conditions, therefore, sufficient winter hardiness is a basic requirement for varieties grown on a large area. The increasing production of southern varieties involves a considerable risk, for which we shall sooner or later pay a high price.

LÁNG, G.: Under the climatic conditions of Hungary wheat varieties showing a genetically unobjectionable winter hardiness can be grown more reliably than those less tolerant to frost. The Italian and French wheat varieties at present included in commercial production belong to the latter category, so their production involves a certain risk. It would not therefore be advisable to sow a large proportion of the wheat area with these varieties. Nevertheless, it is worth utilizing their high yielding ability to such an extent that the substantial losses which might occur in a severe winter should not cause irreparable damage to the national economy. In fact, owing to their earliness and relative tolerance to drought these varieties react favourably to certain meteorological factors which threaten the success of wheat production, so the risk involved in growing them is lower than for frost resistant varieties with a longer vegetation period. Thus, their commercial production, besides favourably influencing the volume of yield, reduces the risk of production as well.

LELLEY, J.: The last hard winter in Hungary was in 1962—63. Even then the wheat plots did not suffer too much damage, and no significant yield losses were found in the Italian cultivers either. Such severe winters seldom occur in Hungary. In spite of this, neither the Hungarian breeders, nor those testing foreign cultivars should make concessions as regards winter hardiness. Today cultivers which could cause trouble in this respect are only grown on a very small area. When breeding and testing new cultivars winter hardiness must be judged by the same strict standards as have been applied so far.

Pogácsás, Gy.: Agricultural production always involves a certain amount of risk. Growing wheat varieties introduced from southern countries does not exceed this normal risk, though a few wheat fields sown to such varieties may be thinned or destroyed by frost once every quarter of a century. Frost damage can be prevented with the proper cultural practices.

Pletser, J.: The mild winters of recent years made it impossible to select the winter wheats introduced in Hungary from southern countries for winter hardiness. It would be risky to produce them on large areas. When the decision was made to disseminate San Pastore only a few years were taken into consideration, which is why the first cold winter caused large yield losses. Data on the frequency of minimum temperatures, as measured at three stations: Magyaróvár, Kecskemét and Nyíregyháza, are presented in Table 1. In the table 0% indicates the lowest and 100% the highest minimum measured so far. Even from this small table it can be clearly seen that under the climatic conditions of Hungary temperatures of —15 to —20°C, which threaten the wheat stands with destruction, may occur with a 25—50% probability. Therefore, I consider it more rational to grow home-bred winter wheats which are more frost resistant and of better comspotion.

Table 1

Frequency of temperature minima 1901—50
*(Bacsó, 1959)**

Month / Frequency	Magyaróvár			Kecskemét			Nyíregyháza		
	XII	I	II	XII	I	II	XII	I	II
0%	−19.5	−25.6	−28.5	−32.2	−32.2	−32.2	−27.8	−26.7	−27.8
25%	−13.1	−16.5	−15.2	−21.5	−17.8	−17.0	−20.0	−18.8	−16.7
50%	− 9.8	−12.6	−11.2	−17.5	−14.5	−12.0	−17.6	−16.5	−12.2
75%	− 6.0	− 7.7	− 7.6	−15.0	−11.0	− 7.8	−15.9	−10.8	− 8.0
100%	− 1.9	− 1.6	− 1.5	− 7.6	− 3.2	− 2.8	− 7.6	− 5.2	− 1.2

* Bacsó, N. (1959): Magyarország éghajlata (The climate of Hungary). Akadémiai Kiadó, Budapest, 184—210, 232—245

Romány, P.: Wheat varieties originating from southern countries have become positively selected for winter hardiness in the course of several years of reproduction in Hungary. Their winter hardiness is better than that of the original (e.g. Libebulla), but due to their genetic properties their sensitivity to frost continues to be higher than those of the Hungarian or Soviet qualified varieties, and for this reason in hard winters they may be severely damaged by frost.

Rosta, K.: The maintenance of wheat varieties originating from southern countries does not take place in Hungary. These wheats are in cultivation for 3—4 years, including the propagation of seed. As I see it, some sort of selection does occur, but this period is not long enough for complete acclimatization. In dry cold winters part of the crop is likely to be destroyed. These varieties are grown at lower risk in the southern parts of Transdanubia and the Great Plain, but even there the crop should be protected from frost damage by deeper sowing, in which case tillering takes place deeper below the soil surface and the shoot initia are exposed to frost to a lesser extent.

Semjén, I.: Most varieties introduced into Hungary from southern countries can be safely grown even in continental winters, if the agrotechnical requirements are strictly observed. The preconditions of safe overwintering are: optimum sowing time, appropriate soil preparation, good quality sowing and optimum sowing depth. Frosts in the dry winter of 1975—76, for example, caused damage to the Libellula stands only where agrotechnical faults had been made (the seed was smeared into the mud, etc.). Plants sown deeper were not affected by frosts at all. Wheat stands damaged by frost in strips (some of the openers did not go deep enough) and suffering thereby 15—20% losses recovered satisfactorily and gave almost full yields. The careful preparation of winter crops is thus highly important.

In my experience the so-called southern varieties, which have been known for about 15 years, have not suffered substantial frost damage either at Mezőszilas (in 13 years) or at Sárszentágota (in 4 years) in spite of their poor winter hardiness. There has not been a single case where a plot has had to be ploughed out either totally or partially for this reason. The agrotechnical instructions were, however, strictly observed in every case. Whe have not had the opportunity to find out whether their resistance to frost was exclusively due to this, because sowing with incorrect agrotechnics, as a control, has not been carried out.

Thus, we have to draw the conclusion that, taking into account the average conditions, these southern varieties can be safely grown in Hungary. Their winter hardiness may not be equal to that in varieties capable of tolerating much poorer conditions, more severe winters, or incorrect cultural practices, but this only causes problems under extreme weather conditions, in unusually hard winters, which seldom occur in Hungary.

SZALAY, D.: Wheat varieties of southern origin (Libellula from Italy, Sava from Yugoslavia) which have been cultivated in Hungary for many years are subject to a certain degree of natural selection depending on the cropyear. However, the hereditary features (e.g. the limits of winter hardiness) in the varieties do not change essentially. Substantial adaptation cannot be expected even after several years, since the maintenance of these varieties takes place at the original breeding site.

Since Libellula and later Sava were introduced into cultivation (in 1968 and 1975, respectively) extremely cold winters (with daily minimum temperatures below —20°C over a fairly long period) have not occurred on the Hungarian Great Plain, so no significant frost damage has been observed in these varieties. They also tolerated the low temperatures in the autumn of 1975 and the spring of 1976 (at the end of November 1975 a seven day cold period occurred with a minimum air temperature of —14.0°C and a radiation minimum of —14.5°C. The mild winter of 1976 was followed by a cold March. On 12th March an air temperature minimum of —13.8°C and a radiation minimum of —17.0°C were measured with a 3 cm thick snow cover). With reference mainly to the frost in March 1976, many people are of the opinion that the production of both varieties is free of risk, since no thinning was observed. It must not be forgotten, however, that below a critical temperature minimum characteristics of the variety frost damage suddenly increases. A wheat stand which tolerates —17°C without thinning out to any considerable degree may suffer more than 50% frosting after the temperature has fallen below —20°C.

In growth chambers the frost tolerance of the varieties can be determined, and expressed as a percentage of that of the given standards. However, the actual winter hardiness of the varieties can only be checked under natural conditions. The next severe winter (similar to that in 1962/63) will decide which varieties can survive exposure to the occasional extremes of climate experienced in Hungary. At present the frost resistance level of Bánkúti 1201 and Bezostaya 1 is considered to be a precondition of reliable wheat production.

In January 1963 minimum temperatures below —10°C were measured over a period of 20 days at Martonvásár.* The lowest air temperature was —21.2°C, and the radiation minimum —25.3°C. In that year at the Experimental Farm of the Agricultural Research Institute of the Hungarian Academy of Sciences, near Martonvásár, more than 50% of the plants in the Etoile de Choisy plots perished due to frost, so that those plots had to be resown. In 1940/41 the winter was even more severe.

The improvement of the growing conditions, particularly ploughing carried out in due time and to an adequate depth, and an abundant and balanced nutrient supply, decrease winter damage to wheat. At or below the optimum sowing depth (4 cm) the soil temperature does not decrease as much as it does on the surface. The root system is the part of the plant most sensitive to frost. Transistor measurements point out a sharp temperature difference between open soil surfaces and those covered by plants. Further, we know that the increased concentration and viscosity of the cell sap generally provides better frost resistance. And this may be attained by introducing 500—600 kg/ha fertilizer active agent into the soil.

It is thus likely that genetically established frost resistance poorer than what was required 20—30 years ago is satisfactory today. This cannot, however, produce a difference of more than a few degrees Celsius in the limits of winter hardiness.

I think the production of Libellula, Sava and other varieties with similar frost resistance is justified in Hungary due to their favourable properties, but only on a

* Th e temperature data are the results of observations made at the Martonvásár Agrometeorological Station of the National Institute of Meteorology.

limited area, so that if they should be destroyed in the winter this would not make it necessary to import wheat (e.g. some 25—30% of the total wheat area of Hungary). In the case of frost damage this area could be utilized for early spring cereals or maize.

TULCZ, I.: Winter hardiness has always been an exciting question for farmers in the case of unknown wheat varieties. Members of the older generation will remember the wheat varieties introduced from southern countries in the sixties, which gave very large yields for one or two years, but which were withdrawn from production after being destroyed by frost on large areas. To give an example: in 1960 the variety San Pastore was grown on 40 ha in our co-operative farm and gave an average yield of 61 q/ha, with the application of 70 kg/ha total fertilizer active agent. In the subsequent years this variety was destroyed by frost and was completely withdrawn from production.

In my opinion, in the acclimatization of the variety Libellula an important role was played by the fact that for some years following its introduction continental winters did not occur in Hungary. In the first years a considerable extent of thinning was observed during the winter, but in recent years this has not occurred any longer. True, the sowing time has been changed in the menatime, in order to protect the stand against fungal diseases. In the last 4 years sowing has begun in October instead of around the previous date of 20th September.

As I see it, Libellula can now be safely grown under Hungarian conditions.

One must be very careful with all the southern varieties recently introduced into Hungary. They should not be included in commercial production until they have been grown for several years on a small area.

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PÁL, GY.: **The efficiency of foliar fertilisation applied to wheat and the action mechanism o leaf sprays are problems which have been much discussed for several years, because according to our present knowledge nutrients sprayed onto the leaf surface of wheat can be taken up only through the stomata. Since spray fertilizers applied to the foliage dry very quickly on the leaves, is it possible that the small quantities reaching the stomata can result in yield surpluses, or do the nutrients sprayed onto the leaves exert their yield-increasing effect through the soil, having previously been washed off the leaves by the rain?**

BEKE, F.: The effect and action mechanism of leaf spraying are still much debated questions. In certain cases the effect is undoubtedly highly positive, especially when the leaf spray contains microelements, or when the temporary nutrient shortage of the stand can be compensated with a minimum quantity of active agent. Top dressing carried out too early in a single dose does not always mean a maximum nutrient supply, especially during the main period of growth. Fractionated nutrient applications, including leaf spraying, are in most cases efficient.

BÓCZ, E.: Many years of investigation on foliar fertilization in wheat have not yielded the expected results. Of all the field crops it is primarily from plants belonging to the Papilionaceae family that an acceptable yield surplus has been obtained.

CSONTOS, M.: The problem raised could be the subject of a very interesting series of experiments, which would be of great practical use in all branches of plant growing.

The experience obtained in the course of large-scale farm management cannot provide answers to this question and may lead to the wrong conclusions.

DÉVAY, M.: The idea of supplying nutrition otherwise than through the root system, together with the fact that plants are able to take up nutrients through their leaves provided a sound basis for the practice of foliar feeding. The procedure, which has been widely applied to different plants, has mainly been of use in providing a partial solution towards making up for the deficiency of microelements and supplementing nutrients which may be closely bound in the soil, and has ensured the expected volume of yield by reestablishing the metabolic balance in the plants.

With the intensification of agricultural production the question of foliar feeding has repeatedly come into prominence. In this respect the results of foliar fertilization experiments are far from being uniformly positive, apart from cases where the rapid elimination of deficiency symptoms was the aim.

The higher rate of fertilization, and the difference in physiological properties between high yielding plants and those formerly produced under extensive conditions necessitate the revaluation of our ideas on the theoretical principles of foliar feeding.

It is likely that high rate nitrogen, phosphorus and potassium fertilization also necessitate the simultaneous supplementation of microelements in the soil. In that case it may be worthwhile applying foliar fertilization, but only after careful consideration of whether the same results cannot be attained by supplementing the microelements simultaneously with the distribution of basic fertilizers, thereby saving the substantial surplus costs of spraying.

Foliar fertilization is undoubtedly suitable for introducing certain bioactive substances, e.g. photosynthesis stimulants, into the leaves, with the simultaneous application of certain micro- or macroelements. In cases, however, when the aim is other than the elimination of some nutrient deficiency, in applying foliar feeding we should take into consideration the fact that we are dealing with a plant with a more or less harmonious metabolism, in whose leaves the mechanism of nutrient uptake and utilization may be different in part from previously examined forms of metabolic deficiency.

Another essential question connected with the application of foliar fertilization to cereals is the nutrient absorption in the leaves. Considering the rather thick cuticle of the wheat leaf, the nutrient uptake was earlier assumed to take place exclusively through the stomata. Today the cuticle is no longer regarded as a homogeneous lipophilous layer, but rather as an aggregation of polymerized cutin molecules interrupted by intermolecular spaces "lined" partly with hydrophilous and partly with lipophilous molecules. It is due to the hydrophilous molecules found here that the water molecules are able to penetrate through the cuticle (cuticular transpiration). It is also known that the spaces between the cutin aggregates are able to let through not only the water but also the molecules dissolved in it, if an appropriate concentration gradient can develop between the two sides of the cuticle (Schönherr—Bucovac 1973) (Schönherr, J.—Bucovac, M. J. (1973): Ion exchange properties of isolated tomato fruits membrane. Exchange capacity, nature of fixed charges and cation selectivity. Planta (Berlin), **109**, 73—93).

Yamada *et al.* (1966) (Yamada, Y.—Rasmussen, H. P.—Bucovac, M. J.—Wittwer, S. H. (1966): Binding sites for inorganic ions and urea on isolated cuticular membrane surfaces. Amer. J. Bot., **53**, 170—172) pointed out by isotope experiments that ions dissolved in water were able not only to penetrate the cuticle but also to become closely bound to certain sites on it. The authors demonstrated with onion leaves that these cuticular sites coincided with the ectodesmal sites of the outer epidermal walls. They suggested that substances which penetrate the cuticle could also penetrate the cell wall by means of the ectodesmata. Franke (1975) (Franke, W. (1975): Stoffaufnahme durch das Blatt unter besonderer Berücksichtigung Ektodesmen. Die Bodenkultur, **26**, 331—341) has arrived at the conclusion that the formations described so far as ectodesmata are hollow spaces in the cellwalls lined with some sort of reducing material. Accordingly, the ectodesmata cannot, in fact, be regarded as morphological structures, but rather as parts of the wall, with special physico-chemical properties, which allow material transportation to take place. The ectodesmata, which are seen as bundles, are thus composed of numerous interfibrillar spaces. Merkens *et al.* (1972) (Merkens, W. SS.—De Zoeten, G. A.—Gaard, G. (1972): Observations on ectodesmata and the virus infection process. J. Ultrastruct. Res. **41**, 397—405) used a special silver impregnation method to make these formations suitable for electronmicroscope studies. These photos clearly show the structure of the cellulose fibrils too. Franke (1975) (Franke, W. (1975): Stoffaufnahme durch das Blatt unter besonderer Berücksichtigung Ektodesmen. Die Bodenkultur, **26**, 331—341) has demonstrated that under normal conditions at the sites of the ectodesmata water molecules may be emitted on the surface of the cuticle; they then accumulate on the leaves in the form of microdrops. It is interesting to note that the areas around the stomata did not take part in these processes. It is probable that in material uptake by the leaves the main role is played by the space between the cutin molecule aggregates and by the ectodesmata.

As regards the material uptake by wheat leaves, it is again probable that the spaces between the cutin aggregates and the ectodesmata represent the special way in which the material uptake and transport are realized. This possibility is suggested by the data of Panic (1970) (Panic, M. (1970): Über die Aufnahme von 2,4-D durch Bohnen- und Weizenblätter in Beziehung des Ascorbinsäuregehaltes. Diss. Univ. Bonn), who demonstrated that the 2,4-D uptake of wheat leaves is bound to the ectodesmata. It is also possible that in wheat leaves, as in onion leaves, there is an exudation of water molecules through the ectodesmata, which makes nutrient uptake from the leaf surface possible even if the drops of foliar fertilizer have practically dried up. A knowledge of the number of ectodesmata on the leaves of individual wheat varieties is a precondition for considering the efficiency of nutrient uptake through the leaves. However, no data are available in this connection. Panic (1970) however, (Panic, M. (1970):

Über die Aufnahme von 2,4-D durch Bohnen- und Weizenblätter in Beziehung des Ascorbinsäuregehaltes. Diss. Univ. Bonn) made the noteworthy statement that in the wheat variety Little Club the number of ectodesmata per unit leaf area was higher at 15°C than at 36°C. This fact suggests that the number of ectodesmata is far from being constant as regards either the variety or the environmental effect. This will undoubtedly provide a further basis for deciding the efficiency of foliar fertilization and choosing varieties susceptible to the treatment.

On the basis of the data presented and the questions raised in this short contribution it is clear that with respect to wheat there is virtually no theoretical basis for the efficient utilisation of foliar fertilization at the present level of agrotechnics. Without knowing the mechanisms of material uptake and utilization in the leaves of wheat, a plant with a balanced metabolism, this procedure cannot be rationally applied in order to increase the volume of yield in this crop.

ERDEI, P.: In order to give a concrete answer to this question investigations should be made on the position (erect or bent), size and waxiness of the leaf, and also on the type of leaf spray, the manner of distribution (in or above the stand), the kind of additive, the size of the drops, etc. Without these data only speculative answers can be given to the question, which are not of much use.

KÁDÁR, A.: Leaf sprays act by entering the plant through the foliage. When washed off by rain and taken up from the soil by the roots they exert little effect. Leaf sprays which also contain microelements have a favourable influence on the metabolic processes of plants, and ensure immediate nutrition to the plant during critical periods. Their effect is best felt if the plant has a sufficiently large active leaf surface suitable for the uptake of nutrients. Leaf sprays play a part in improving both the quantity and the quality of the yield.

KISS, Á.: The question of foliar fertilisation requires further reliable experimental results. It may be that nutrients do not enter the plants only through the stomata; absorption between the epidermal cells is also a possibility. Some effect may also be exerted through the soil.

Besides the field trials the correct final answer to this question will be given primarily by reliable, parallel laboratory and phytotron experiments.

KOLTAY, Á.: The efficiency of foliar spray nutrition was studied for years in experiments carried out with Bezostaya 1, and later with Fertődi 293 too, sown in a 5×5 Latin square design on a forest residue chernozem soil at the Agricultural Research Institute of the Hungarian Academy of Sciences. The influence on the grain yield of 5, 10 and 20 kg/ha urea spray fertilizer, containing nitrogen as the active agent, was first studied on a soil of poor fertility, and later under more intensive conditions together with a higher rate of soil fertilization. The nitrogen solution was sprayed over the crop with a high pressure motor sprayer in the period between heading and flowering, on each occasion in the morning hours. The control plots were sprayed with tap water, and the largest dose (20 kg/ha) was applied in a solid form as well, by scattering it over the crop. Of 12 experiments carried out in 5 successive years only three resulted in a small yield increase on the borderline of significance, in each case with Bezostaya 1. The grain yield of the variety Fertődi 293 was not reliably modified by the treatments. Weed killing experiments were also carried out with Dikonirt, applied in combination with urea foliage spray. No reliable difference in yield could be observed between the Dikonirt treated control and the plots given Dikonirt + urea.

There would be importance in supplying the missing microelements through the leaf, since there are indications that the microelements are more efficient when supplied through the leaf than when they act through the soil. A precondition of successful microelement nutrition is, however, a precise survey of the deficiencies.

LÁNG, G.: A number of researchers have achieved favourable results with the foliar nutrition of wheat. The basic nutrient requirements of the plant are covered by nutrients entering the plant through the soil and root. However, macro- and microelements absorbed through the leaf, although small in quantity compared to the total requirements of the plant, may exert a favourable influence by directly entering the metabolism. Because the prospective yield increase is so low the foliar nutrition of wheat is usually only economical if the foliar spray can be combined with a necessary plant protection operation. Chemical weed control offers a prime opportunity to supplement the nutrient supply, particularly nitrogen, through the leaf.

LELLEY, J.: The results of experiments with foliar nutrition in wheat are not promising, and often not even consistent. The expensiveness of the procedure and the difficulties of implementation cause much concern. Experience seems to prove that grain filling and a possible improvement in quality can best be promoted with foliar nutrition immediately before flowering. At that time, however, spraying can only be carried out from a helicopter. In my opinion, a suitable application of fertilizers before sowing and early in spring makes this uncertain method of nutrition superfluous.

NAGY, B.: The soil has nothing to do with the efficiency of foliar nutrition on wheat. In putting the question the following points were left out of consideration:

a) there is dew every night, which is an important survival factor for cereals, particularly in dry periods;

b) the fact that the foliage of cereals has an active metabolism was demonstrated long ago by, among others, Soviet and American physiologists.

The efficiency of foliar nutrition is due mainly to the fact that in cereals, as generally observed in every important crop, after the appearance of the generative organs the nutrients are transported from the leaves to the generative organs, in the present case to the ears, so that the efficiency of nutrient uptake is concentrated here. On the other hand, the microelements in chelate type foliage sprays greatly improve the nutrient balance and with it the biological and physiological vitality of the wheat. In our opinion the details of the physiology of nutrient uptake must be further studied and followed in the relevant literature in order to improve both the foliage sprays and the treatments. However, the results obtained in 1976 unanimously show that in cereals treatments applied once at the time of flowering and once at the stage of milky ripeness should be considered as technological procedures, applied with less nitrogen and more magnesium, phosphorus and microelement chelate in rainy weather, and with increasing amounts of nitrogen and chelate in dry weather.

PETRÓCZY, I.: We are convinced of the usefulness of foliage spray applied to wheat. It is true that when it is distributed from an aeroplane little of the spray is absorbed immediately, as it quickly dries up. It must not be forgotten, however, that the morning dew ensures the continuous absorption of the spray. (It is only after long periods of drought accompanied by intensive air motion that dew is not formed at dawn during harvesting. It is a well known fact that the work of the combines is limited by the abundant dew. Furthermore, the fact that water is actually taken up is proved by the 2—3% higher water content of wheat grains in the morning hours.

The continuity of absorption is confirmed by the results of examinations performed with the stable N^{15} isotope. Labelled urea is absorbed by the leaves of plants at a faster rate at night and in the morning hours than in the daytime.

The experiments carried out in 1976 prove unambiguously that foliar nutrition should be introduced all over the country. Taking into consideration the yield averages of more than 30 farms, treatment with Wuxal and Mikramid results in a surplus yield of 4 q/ha. Their importance is increased by the fact that they can be coupled with operations for controlling powdery mildew and Fusarium. Further investigations are necessary to determine the optimum time and number of the treatments as well as the composition of the spray.

Beyond any doubt, distribution by aeroplane represents a simple, highly economical method for increasing the volume of yield.

We must not forget the relationship between substances excreted on the leaf surface of wheat (exudates) and foliar nutrition, in relation with the application of Wuxal and Tomasol. Works dealing with infection caused by phytopathogenic fungi discuss the role of exudates in infection and try to clarify their chemical composition. Several dissertations prepared on this subject in our department have produced results of practical importance. We feel that the presence of cuticular exudates (excretion) and the correctly timed application of foliar nutrition may provide further aspects for the improvement of disease resistance and the increasing of yields.

POGÁCSÁS, GY.: According to my investigations leaf nutrition in wheat resulted in each case in a yield surplus. I did not study the action mechanism, because in dry weather the leaf spray acted through the leaves; when washed off by the rain, on the other hand, it was dissolved in the soil and absorbed by the roots, and was effective all the same.

The question has not been clarified; it would be worth carrying out experiments on this subject.

ROMÁNY, P.: Wheat demands nutrients of different composition and quantity during the vegetative period. There are periods when certain nutrients are required in different quantities, and if these are not adequately supplied the development of the plant may be hindered.

Foliage fertilization makes it possible to correct the deficiencies in the nutrient supply taken up through the soil; by means of leaf and petiole analyses the plant can be provided with a nutrient solution of different composition, as needed at a given time.

Foliage fertilization solves temporary nutritional problems and has a favourable influence on the nutrient uptake of the plants.

Extensive experiments carried out on large-scale farms in the last few years have generally confirmed the yield-increasing effect and economic efficiency of foliage fertilization.

Further investigations are naturally required to find out in which phenological phases and how often the different plants, including wheat, require foliage fertilization.

TARJÁN, R.: The efficiency of foliar and soil fertilisation is the subject of international debates. In our opinion only nitrogen fertilization applied at a rate suited to the soil and regional conditions will be truly efficient in increasing the yield.

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PÁL, GY.: **Early wheat varieties are given priority in production owing to the favourable scheduling of the harvesting operations and the comparative surplus yield caused by a pseudotolerance to infectious fungi and the probable absence of shrivelled grains resulting from their earliness. Taking their quality into consideration as well, do you think that the early varieties will retain their advantage once a sufficient number of harvesting machines are available and when later varieties either become resistant, or can be protected against the infectious fungi by chemicals?**

BALLA, L.: The advantages of early wheats will probably not only be maintained but also increase in the future, due to the improvement of winter hardiness and quality in the early varieties. Of the certified early varieties only Martonvásári 4 shows unobjectionable winter hardiness and quality at present.

Early varieties have the undisputable advantage of producing larger yields due to the fact that fungal pathogens, particularly stem rust and foot diseases, do less damage to them, while they can be harvested at the stage of biological maturity, with minimum loss and maximum test-weigth. A further advantage is that the harvesting of these varieties can be started earlier, so a smaller proportion of the wheat will be harvested when overripe, which would result in a higher loss and lower test-weight. Cereal crops which remain in the field late often suffer great damage from rain and wind. To avoid this, breeding should be aimed at shortening the vegetation period. The optimum length of the harvesting period is 12—14 days, which can be attained by growing early and medium early varieties.

BEKE, F.: Under the dry weather conditions of Hungary early wheat varieties have so far shown higher yield reliability than later ones. This can partly be explained by pseudoresistance, but the main cause is that the sudden hot weather, which usually sets in around harvesting time, results in increased transpiration, and evaporation from the upper soil layer is unable to replace this water. The increased transpiration causes a cation accumulation in the immediate neighbourhood of the roots which paralyses the water uptake on droughty days. The early varieties partly or totally precede this critical period. This is why the yielding ability of late varieties, which usually give larger yields, is greatly dependent on soil and weather conditions. Consequently, Hungarian conditions make the production of late wheat varieties unreliable.

BELEA, A.: For reasons of farm economy and yield reliability the early varieties will remain highly important. Irrespective of their pseudoresistance the early varieties are generally more resistant to the summer drought which frequently occurs in Hungary than the late ones. Farms would do better to buy only as many combines as are required for harvesting without loss. Many machines lie unexploited in the farms for most of the year. It would be useful to introduce two-course harvesting in Hungary, which besides better machine utilization is one of the prerequisites of quality wheat production. In that case no expensive drying equipment is needed.

BÓCZ, E.: Wheat varieties with a long vegetation period, which were excluded from agricultural production in the past decades, have recently been introduced into cultivation. It is a fact that, due to increased soil fertility, varieties with longer vegetation periods have also given satisfactory yields. In certain cropyears, however, varieties with a longer vegetation period have failed as they used to do previously, mainly for reasons connected with water management. In my opinion, of all the factors that may be involved, attention should be paid primarily to the water supply and secondly to fungal infection. In Hungary a sudden water deficiency occurs at harvest time, which increases the shrivelling of the grains; this is why the old estates preferred growing varieties which mature before that date. Markedly dry summers only occur with a 50—60% frequency, which explains the misleading performance, or selection, of certain varieties. The recent wide-spread fungal infections cause a rapid deterioration in the period following milky ripeness. The deterioration of the variety Kavkaz definitely seems to be of fungal origin. The effects of these two factors unequivocally suggest that century-old experiences are still worthy of our respect.

Of course, both mechanization and the increased resistance and improved properties of the varieties may alter this situation, especially if several years of practice confirm their higher yielding ability even in critical years.

CSONTOS, M.: Early varieties should still be reckoned with in determining the ratio of varieties to be grown even when the problems raised in the question are solved. It is of primary importance to lengthen the vegetation period by sowing varieties with different ripening times in order to eliminate the effects of extremes of weather (e.g. yield losses caused by drought or by shrivelled grains).

Further, it should be mentioned that rational farm management necessitates an increase in the efficiency of agricultural machines, including not only the harvesting machines but also those for subsequent operations. In other words, every effort should be made to achieve a better exploitation of agricultural machines.

Resistance to fungal infection should be increased in the early wheat varieties.

ERDEI, P.: Under the climatic conditions in Hungary the importance of early wheats is not determined exclusively by pathological reasons, but also by growing conditions connected with the weather.

In early wheats the grains are less inclined to shrivel than in late ones. From this point of view the advantage of early varieties cannot be denied.

JOVAN, D.: Under Hungarian conditions the protraction of the harvesting period by widening the range of varieties is definitely justified. The number of combines, taking into consideration the capacity of the machines and the time available for harvesting, is determined by the size and crop yield of the wheat area, both on a national and on a farm scale. No other crop, not even maize, which is very important in Hungary as regards area and yield alike, demands as large a number of combines as wheat does. The number of combines should therefore only be increased to the optimum profit limit, or possibly reduced with a parallel increase in the capacity of the combines.

Early wheat varieties prolong the harvesting period, thereby improving the exploitation of the combines. This is advantageous in many respects: transportation, straw harvesting, tillage, employment, labour peak reduction, management. If these advantages can be realized without any considerable loss of yield by sowing the proper ratio of early and late wheat varieties, the importance of early wheats from the point of view of mechanization may be quite considerable.

KISS, Á.: Under Hungarian conditions early wheat varieties will always have the advantage over late ones. If a sufficient number of harvesting machines were available more time could be spent on soil preparation, and the second crop which is sometimes necessary (e.g. in 1976) would perhaps be more reliable. Chemical control should not be employed if it is not strictly necessary. As much care as possible should be taken to protect the environment.

KOLTAY, Á.: The results of harvesting experiments carried out in the past decade show that modern, high yielding wheat varieties should be harvested directly with combines within the shortest possible time after the beginning of full ripening. The experiment also showed that the harvesting optima of the varieties were extremely close. A harvesting capacity capable of fully covering the above requirements will not be available in the future either. With a view to the better utilization of the machines and the fulfilment of the harvesting optima it would be reasonable to grow early, medium and late varieties on the same farm. A well chosen ratio of varieties with different ripening times has another great advantage beside harvesting without loss: the smaller production risk. In some years the earlier, and in other years the later varieties may produce more reliable yields. It is therefore imperative to make an adequate range of varieties available for commercial production.

KURUCZ, GY.: Wheat varieties with different ripening times form the basis of efficient wheat production if they have approximately equal yielding ability, or if the yield differences resulting from the ripening time do not threaten production profitability. "A sufficient number of harvesters" is a vague term. The rising prices of machines, the decreasing number of workers (particularly technical staff) employed in agriculture, and the economic utilization of mechanical, drying and storage capacities in the farms all call for a longer harvesting period and for the assuring of harvesting optima for all varieties. The rainfall which frequently occurs at harvest time also has an adverse effect sometimes on the earlier, sometimes on the later varieties. For all these reasons the range of varieties should be wide enough to ensure a harvesting period of 14—20 days within the optimum harvesting period. Using wheat varieties from only one ripening group (early, medium or late) it would be impossible to ensure the economic efficiency and profitability of wheat breeding in Hungary.

LÁNG, G.: Early varieties will continue to be of great importance in the future, mainly because the risk of production can only be kept at an acceptable level by growing varieties with different vegetation periods. They also have a favourable effect on the economics of wheat growing by saving the expense of overmechanization.

LELLEY, J.: The greatest advantage gained by producing early wheat cultivars is that they suffer less damage from drought and ripen before rust can cause serious yield losses. The more efficient utilization of the combines is also an aspect not to be ignored.

The experience gained so far shows that the yielding ability of cultivars classified as early in Hungary is almost identical with that of medium early cultivars. I think breeding for earliness and the growing of early cultivars is reasonable as long as earliness does not interfere with a further increase in yielding ability. Once we arrive at a point where the national yield averages can only be increased by breeding cultivars with longer vegetation periods, the production of early cultivars must be restricted. With a view to the better organization of harvesting operations an approximately 20—25% proportion of early cultivaras must be maintained. The level reached by agrotechnology is still far from fully exploiting the potential yielding ability of commercially produced cultivars. For this reason a change-over to breeding late cultivars is not to be expected for some time. We must not forget, either, that in that case the role of breeding for pathological resistance will be even more important.

NAGY, B.: Provided either the breeder or the plant protector is able to make later ripening varieties free primarily from Fusarium, a certain proportion should be kept in production owing to their potential yielding ability. From the point of view of plant protection the efficient application of foliage spray + fungicide combinations on many thousands of hectares has brought this prospect nearer.

PETRÓCZI, I.: In my opinion, there will always be a demand for early, medium and late wheat varieties. This will offer more possibilities for fighting off unexpected epidemics and gradations, taking into consideration the number of spraying days too. The restriction of the genetic basis and the reduction in variability, parallel to the monoculture and large-scale production may hold great danger of unexpected epidemics. Even if a sufficient number of combines are available we still maintain this opinion since in rainy weather quicker harvesting and drying substantially reduce the extent of mildewing in the grains, and thus the mycotoxicoses cause fewer sanitary problems.

POGÁCSÁS, GY.: I have studied the average wheat yields of farms, and the proportion of early, medium early and late varieties on a farm-scale. According to the available 15 years' data early varieties have always given larger yields than medium or late ones.

In my experience early varieties show better adaptation to the climatic factors of Hungary than medium or late varieties.

According to my calculation the production of early varieties alone could be economically efficient with increased combine capacity. Disease resistance in medium and early varieties remains a mere hope for the present. Once such varieties are available I shall clear up the question in farm-scale trials.

PLETSER, J.: The uneven distribution of precipitation in Hungary may threaten the harvest any year. To prevent yield losses from this cause a sufficient number of harvesters are also required, but even then the protraction of the harvesting period by including early wheat varieties may be advantageous in increasing the reliability of production.

The number of rainy days in July is 8—13 on a fifty-year average. The probability of rainfall on an average July day is 20—40%. The distribution of the precipitation is highly variable in Hungary in both time and space. The precipitation in July ranges from 0 to 250 mm on areas suitable for wheat production. Precipitation at least 25% more than the average over many years may occur in July two or three times every ten years.

Drier summers which ensure an undisturbed harvest also justify the propagation of winter wheats with a shorter vegetation period, since in these varieties the grains are less inclined to shrivel than in wheats with a longer vegetation period.

It is characteristic of the continental climate of Hungary that the monthly precipitation may be three times as much as the average in certain years, while the minima approach zero. The median, the value of 50% frequency, is lower than the average over many years. This means that in the full series of meteorological data there are more monthly precipitation values below than above the average. The higher number of dry months is compensated by a lower number of months which are much rainier than the average. Drought is thus more frequent than excess rainfall. Precipitation conditions fulfilling all requirements are very rare.

In order to plan wheat production efficiently the proportion of winter wheats with different vegetation periods should be determined separately for each part of the country, taking into consideration the regional distribution of precipitation.

ROMÁNY, P.: In my opinion early wheat varieties with a shorter vegetation period will still be in high demand in the future and a further increase in their sowing area would be justified, due to the reliability of their yields (absence or substantial reduction of shrivelled grains, lower extent of damage caused by various diseases), as well as to certain advantages of farm management. Even if later ripening varieties are more resistant, drought and other weather conditions unfavourable for the process of ripening may continue to cause damage to wheat.

It is desirable to grow wheat varieties which ripen one after the other, because in this way harvesting can be carried out at the optimum time, with a smaller number of machines and minimum waste.

ROSTA, K.: Under the climatic conditions of Hungary, in most years a period of drought sets in at the beginning of July. In the rainier western, northern and north-eastern parts of Hungary there is less danger of shrivelled grains, therefore in these places medium late wheats should also be grown on a small area besides varieties belonging to the early and medium early maturity groups, in order to prolong the harvesting period and utilize the machines better.

In the larger part of the wheat area, mainly on poor soils or in regions particularly exposed to drought (e.g. Karcag, Turkeve), I think it reasonable to give preference to the early varieties. This applies primarily to varieties showing intensive tillering, as grains produced on laterals often shrivel. In choosing the maturity groups of the varieties the danger of drought is a factor at least as important as the possibility and extent of infection by fungi. In most areas of Hungary I do not think that breeding for resistance will be able to remedy the unreliable production of late varieties.

With a view to the reliability of wheat growing I suggest the following ratios of varieties: 40—45% early, 45—50% medium early and 8—10% medium late wheat varieties.

SEMJÉN, I.: As I have mentioned already, the so-called southern varieties are easier to thresh and clean, show a higher resistance to infectious fungi, their grains are less inclined to shrivel, and last but not least, since they can be harvested before the summer rainfalls their quality is easily preserved. In my opinion, to sow late varieties simply in order to lengthen the harvesting period is not justifiable for various reasons; nowadays even the shortage of harvesting capacity is no longer an acceptable reason. To the best of my knowledge there has been an excess supply of harvesters and combines for years in Hungary. Deliberate late harvesting (either by choosing late varieties, or for other reasons) is a luxury, which may and does involve multiple losses in a single season. The really expensive combine is the one that is missing when it is most urgently needed. The lack of combines may cause losses of several millions, which would pay for the missing combines many times over.

On he basis of the reasons given above I am of the opinion that the early varieties will have considerable advantages even if the resistance of the latter varieties is solved, or if chemical disease control becomes reliable. An essential change is only to be expected if their resistance should be coupled with a yielding ability considerably higher than that of the early varieties. This would give them absolute superiority even considering the unfavourable weather conditions at the time of harvesting.

Apart from this, we must not consider all early varieties to be of uniformly poor quality, nor regard all late varieties as of uniformly excellent quality.

It would be important to have reliably yielding, easily threshed, firm-stalked, early, resistant wheat varieties at our disposal as soon as possible. Once this were realized, better and better varieties would appear, and the speed of variety replacement would only cause trouble to the producers in following the appearance of the valuable varieties.

In my opinion there is every hope that the demands of the producers will soon be fulfilled by the breeders.

SZALAY, D.: The production of early wheat varieties has many advantages in Hungary. Apart from farm management and production technology aspects their pseudotolerance to rust species, particularly to infection by stem rust, is extremely important. The disastrous rust damage caused in 1873 mainly to local varieties in the Tisza region (Tisza-vidéki) has not occurred again because the Hungarian varieties grown since then have a shorter vegetation period. One of the most important advantages of the variety Bánkúti 1201 over the former varieties (local varieties) was its earlier ripening. In most years varieties ripening by the end of June are not attacked by leaf rust (*Puccinia recondita* Rob. ex Desm.). Even when it appears early (in the middle of June) the pathogen does not cause substantial yield losses in the short vegetation varieties. The more dangerous stem rust (*Puccinia graminis tritici* Eriks. et Henn.) only exceptionally appears before the early wheat varieties have reached waxy ripeness. Wheats with a ripening time like that of Rannyaya 12 are thus reliably resistant to this pathogen.

Under Hungarian conditions the early wheat varieties hold the promise of economic advantages and represent a factor of yield reliability. In spite of this it would not be right to base the wheat production of Hungary on a few early varieties. Owing to the differences between cropyears, and with a view to harvesting at the optimum stage it is reasonable to grow medium early, or even medium late varieties parallel to the early ones. The weather conditions in recent years were favourable for the development of early varieties. It is known, however, that a sharp temperature fall late in the spring (after the heading of early wheats) or a delay in the May rains have a more adverse effect on the early than on the later varieties.

In farms with a high mechanization level harvesting takes 10—14 days. A substantial reduction in this period is not justified by either organizational or economic considerations. I think it reasonable to grow at least 2 wheat varieties of different vegetation period on every farm. A 6—7 days' difference in ripening time between the plots harvested first and last will always be advantageous.

Besides the above, the positive correlation between vegetation period and yielding ability must not be forgotten. Though there are forms where this correlation does not hold the fact remains, that, provided the growth and development of the plants is undisturbed, a longer vegetation period ensures the production of a larger amount of organic matter.

SZÁNIEL, I.: Early varieties will maintain their advantage with respect to the cultivation ratio under any circumstances, basically for two reasons. First, in the case of drought the grains are less liable to shrivelling. (This is important even if varieties with a long vegetative period were found to be resistant, or could be adequately protected.) The other reason is connected with harvesting. The problem is not properly formulated by saying: "if a sufficient number of harvesting machines were available". While this would be possible in principle it is an economically absurd proposition. The machines become outdated, and economic efficiency requires that they should have the highest possible output. No farm can afford to harvest its total wheat yield from a single variety within 4—6 days. The optimum harvesting period of 10—12 days can only be realized by growing varieties in different ripening groups; the economical utilization of all machines (combines, transporting vehicles, etc.) used in the harvesting operations has to be ensured through a harmonious selection of maturity groups and varieties. Correct farm and labour management also demands this.

TOMPA, GY.: Many people believe that a rapid increase in wheat yield can be achieved by growing exclusively varieties with a short vegetation period and they support their theory by quoting data on surplus yields.

In my opinion the proportion of the area sown to varieties with a short vegetation period is bound to increase for farm management reasons, but to simplify the question to such an extent as to maintain that higher yields depend on the exclusive use of these varieties would lead to incorrect practice. It is a fact that earlier ripening makes it possible to begin harvesting at the biologically most active stage, which in itself means a relatively larger yield. It is necessary, however, that the harvesting capacity should be adjusted to the area sown to the variety in question, otherwise a loss of yield amounting to as much as 20% may occur owing to the dealyed operations. This could be avoided by sowing another suitably high yielding variety belonging to the next maturity group. Yield reliability must certainly be kept in view and this can be attained, in my opinion, by carefully determining the ratio of varieties with different vegetation periods.

Our medium late wheat varieties are, regrettably, unsuitable for continued cultivation, but this does not mean that we should give up this category. They are needed — even if in a smaller proportion — if the optimum period of harvesting is to be kept to 10—12 days. Without a loss in yield this optimum cannot be achieved with only one ripening group.

The fact that our medium early and medium late varieties are at present more susceptible to certain pathogens means that the breeders and plant protection experts are faced with a more difficult task than in the case of the early varieties, where yield losses caused by pseudo-tolerance to certain fungal pathogens do not occur simply due to the earliness of the varieties.

TULCZ, I.: Earliness, as a genetic feature of the variety, will always be an advantage in wheat under the climatic conditions of Hungary. This can be stated so categorically because in wheat earliness involves no yield reduction as it does in crops sown in spring, where this is an essential point to be considered.

The harvesting capacity must be oversized under any circumstances, as this surplus investment is always recovered. This problem can thus be solved together with successful protection against fungal diseases. However, our present knowledge is not sufficient to prevent the probability that the grains of late varieties will shrivel. Rainfall during harvesting also impairs the quality of late varieties. This deterioration may be substantial. We still remember clearly the 1972 harvest when the last hectares were harvested at great loss.

To sum up, I think that early varieties will come more and more into prominence.

The proportions of early and medium early varieties should be adjusted to the harvesting capacity. Late varieties, except when they are extremely high yielding, should, in my opinion, be withdrawn from production as soon as early and medium early varieties of sufficiently high yielding ability are available.

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PÁL, GY.: **Both abroad and in Hungary foreign and Hungarian wheat varieties, which are known to give the largest yields, to be resistant to infectious fungi and lodging, to have stiff straw and to be winter hardy, are used in breeding. After some time this may result in inbreeding, which in turn may lead to the restriction of the genetic basis and the decrease of genetic variability and the selection interval. Do you consider these consequences to be dangerous, and if so, what measures and solutions do you suggest?**

BALLA, L.: The restriction of the genetic basis is a real danger for breeders in Central and Eastern Europe. Most of the new varieties have been developed from a Bezostaya basis. Some solution must certainly be found to avoid a possible catastrophe. The following tasks should be permanently kept on the agenda:

a) seeking out and crossing wild wheat species,
b) intercrossing wheat varieties differing in origin from the Hungarian ones,
c) using various sources, including the crossing of winter and spring wheats,
d) preserving old and local varieties.

BEKE, F.: The reduction of the genetic basis is less dangerous in wheat than in cross-pollinating plants. The genetic construction of wheat, and crossing with varieties grown under different ecological conditions always ward off the danger of reduction in the genetic basis. I think that anxiety in this respect will be superfluous for a long time.

BÉLEA, A.: Plant breeders generally choose the crossing partners from a rather narrow morphological range. To attain more far-reaching results it is indispensable to widen the initial breeding material by using geographically remote varieties, specific and generic hybrids, irradiation induced mutants which may be useful in practice, etc.

CSONTOS, M.: Genetic deterioration is not expected in the near future, so it does not represent any danger. It should be noted that hybridization has great perspectives in wheat growing, but owing to various unsolved physiological and practical problems it cannot yet be realized.

KISS, Á.: In certain cases sibbing is acceptable. However, the wide international co-operation makes it possible for breeders to use various genetic bases for the improvement of given characters in their intensive varieties. Once the new properties have been stabilized, the material can be diversified by the combination of different types. This is why the establishment of international gene banks is so important, because if the possibility of selecting for a given character has been reduced, the breeder can rely on ancient types to renew the weakened character. Besides crossing varieties, interspecific and intergeneric crosses should still be made, since new species and genera represent a wealth of new genetic combinations. With a view to the further development of cereal breeding a certain amount of energy must therefore still be directed to basic research in genetics, cytogenetics and breeding. Among the new possibilities the stabilized hexaploid, octoploid and tetraploid wheat-rye hybrids are worthy of attention. Moreover, there is a great variety of wheat-*Agropyron* and wheat-*Aegilops* hybrids, and more recently of wheat-barley, wheat-oat and rye-barley hybrids. The practical value of the latter cannot be evaluated as yet, but in the next 15—20 years they may well form tha basis of further development.

LÁNG, G.: In wheat, as in all other crops, the restriction of the genetic basis is harmful. Wheat is extremely rich in forms, and the local varieties, cultivars and variants occurring in the world are far from being exhausted. By means of natural and artificial mutation new forms with different genetic bases are continually being produced. So a too severe restriction of the gene stock need not be feared in the case of wheat.

LELLEY, J.: At the Hungarian wheat breeding stations the breeders work with a highly diversified material obtained from every corner of the world. In places where this is not so, they are committing a serious error. Therefore, for the moment I do not see any danger of a possible restriction of the genetic basis as a consequence of inbreeding. In fact the situation is just the opposite, both in Hungary and on a world scale, since an increasing amount of genetic information originating from very distant genera is being introduced into the wheat genomes by different substitution and addition methods, resulting in a substantial enrichment of the genetic material. A decrease in the genetic variability need not be feared either in Hungary or elsewhere in the world, since mutation breeding also works against it. Anyway, in the different world variety collections, and in the gene banks which have recently become fashionable, every effort is being made to preserve various crossing derivatives as well as the old varieties. This work must be continued, and particular care must be taken of the collections of cultivars. The gene banks are, in my opinion, inferior to the collections of cultivars, as the genetic composition of the material they contain is not clearly defined.

NAGY, B.: The reduction of the genetic basis in large-scale production systems is a real danger, and for the present this trend seems to be unavoidable, and can only be changed by hybridization or other genetic manipulation. Meanwhile care should be taken to maintain former varieties and genetic initial stock which does not sufficiently possess the characters listed in the question, all the more so because in the case of hybridization or gene manipulations these materials can and must be used. This danger is well illustrated by the resistance problems which have arisen in "T" cytoplasmic maize hybrids (*Helminthosporium*, etc. epidemics).

POGÁCSÁS, GY.: In my opinion Hungarian and foreign wheat varieties have great genetic variability and the selection interval is large. From a practical viewpoint I cannot see any danger of its being reduced. This subject, however, more nearly concerns the breeders and geneticists, and it is up to them to decide its importance and implications.

ROMÁNY, P.: The world-wide co-operation which now exists between plant breeders excludes the possibility that the genetic basis will be narrowed down in the coming years. The international exchange of varieties and basic materials has widened to an extent never experienced before. This makes it possible for breeders to use basic materials which are genetically remote. The organized co-operation of plant breeders will always be able to prevent the narrowing down of the genetic basis. Reduction in the selection interval would, otherwise, be dangerous and should be avoided.

SZALAY, D.: The restriction of the genetic basis and variability of the wheat varieties is a real danger today in Central Europe. Due to its excellent properties and good general combining ability, Bezostaya 1 can be found among the parents of almost all recent varieties. The susceptibility of Bezostaya 1 to powdery mildew (*Erysiphe graminis* Dc. f. sp. *tritici* Marchal) and to Fusarium species (*Fusarium roseum* f. *cerealis* (Cke.) Snyder et Hansen, *Fusarium graminearum* Schw.) is well known. Wheats which have Bezostaya 1 among their progenitors may give the same response to infection by the pathogens mentioned and to other diseases, in other words, they may be or become susceptible. By crossing with various resistance sources and carrying out careful selection the danger of possible epidemic diseases can be decreased. Naturally, it should be kept in mind that varieties of identical or partly identical origin also show similar behaviour under the influence of various ecological and other factors.

This does not mean that the use of Bezostaya 1 in cultvation or breeding ought to be restricted. At the medium level of agrotechnics in Hungary this variety gives satisfactory and comparatively reliable yields even today. The value of the new varieties developed with the utilization of Bezostaya 1 will be decided in the course of practice. It may be worth remembering that in the forties and fifties the winter wheat variety Bánkúti 1201 and its derivatives were widely grown not only in Hungary but also in the neighbouring countries without any harmful consequences.

It would be wise to avoid the disadvantageous genetic effects originating from the wide use of Bezostaya 1. This has been made possible by the use of new valuable varieties not related to Bezostaya 1. Besides increasing the diversity, the old Hungarian varieties may also be of use in crossing, owing to their high adaptability to the ecological conditions in Hungary, although from the hybrids of Bánkúti 1201 type wheats forms meeting the current requirements can only be selected after repeated crossing.

As a whole, breeders should aim at having a genetically diversified breeding stock at their disposal, so as to be able to produce varieties with different hereditary bases.

SZÁNIEL, I.: Is the reduction of the genetic basis dangerous? Yes, it certainly is. Breeding will only be successful if carried out with the widest possible genetic basis.

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PÁL, GY.: **The chemical control of those weeds which cause a substantial loss of yield has produced, through selection, a weed flora resistant to the applied chemicals. The use of new herbicides may produce further resistant weeds, and this may continue indefinitely. What solutions can you suggest for the efficient control of resistant weed species developing in wheat stands?**

BEKE, F.: Mechanical weed control will continue to be the principal method of protecting plants against weeds. The higher level of technology and improved cultural practices will gradually reduce the role of herbicides. I believe that the change of herbicides follows changes in the weed flora and its tolerance. Weed control will remain important in places where careful soil cultivation is neglected.

BELEA, A.: Weeds resistant to hormone-based chemicals have recently become widely distributed. The propion derivatives of various hormone preparations have proved highly efficient against dicotyledonous hormone-resistant weeds. Besides testing the new herbicides it is very important to study their effect on the composition and structure of the weed flora, with the purpose of preventing the development of a resistant weed flora by introducing an appropriate herbicide rotation.

Protection from weeds should be made more efficient by the application of up-to-date cultural practices. Proper soil cultivation carried out in due time, adequate crop rotation, etc., are also known to restrict the weed growth in wheat stands to a considerable extent.

BÓCZ, E.: It was predictable that the resistance of weeds would develop more quickly than the demand for herbicides could be satisfied. We have always emphasized that the weed killing effect of soil cultivation cannot be dispensed with. The traditional crop rotation and soil cultivation systems developed with a view to an optimum water supply should be revised, and the possible introduction of new crop rotation systems and further soil cultivation techniques should be taken into consideration.

CSONTOS, M.: Besides applying herbicides an appropriate crop rotation must be maintained. Wheat can be safely sown after wheat on two occasions.

ERDEI, P.: I am afraid the world's highly developed chemical industriy will leave little time for despair. Apart from this, not only the "herbicide rotation" suggested and used today against resistant weeds, but also the well known cultural practices, which are slowly falling into disuse, are efficient means of weed control. Chemical weed control cannot make up for the deficiencies in cultivation often encountered today. It is a pity that the subject of biological protection against dangerous weeds is only dealt with in Hungary in theory, although it is of great significance for the future.

KÁDÁR, A.: The prevalence of weeds resitant to herbicides can be traced back partly to the use of herbicides containing identical active agents, and partly to production in a monoculture. The manner of protection is always determined by the weed conditions in the given field. On the basis of data obtained in an assessment of weeds one can decide on the kind of herbicide to be used, or, if it is necessary and possible, on the discontinuation of the monoculture. With the range of herbicides now available the control of weeds is possible even when cereals are grown in a monoculture, but attention must be paid to the changes caused by different herbicides in the weed composition.

KISS, Á.: Cultural practices will continue to play an important role in weed control. Herbicides must not be used as the only means of protection against weeds, because we shall then be unable to deal with the developing resistant weed flora. Weed control carried out at the right time will only be effective if it is coupled with appropriate crop rotation and tillage.

The development of the weed flora should be followed with constant attention in order that the necessary steps may be taken in due time.

KOLTAY, Á.: The traditional agrotechnical possibilities of weed control should be fully exploited. The correct crop rotation, soil cultivation, farmyard manure free from weed-seeds, pure seed, and last but not least regular weed killing on roads, ditches, fallow land and other places exposed to weed growth, are efficient means of weed control. These factors have been almost completely neglected since the introduction of chemical weed control, which is undoubtedly the most efficient method of protection from weeds and which also requires the least investment. Herbicides do not, however, solve every problem, and may develop a weed flora resistant to the chemicals used. Apart from this, if they are used without observing the instructions, or applied at too high a rate, etc., almost all herbicides have a phytotoxic effect. Unfortunately, many of the new wide-range herbicide preparations, beside their efficient action, have often caused yield decreases in our experiments. Today efficient herbicides against monocotyledonous weeds are already available, and the range will increase in the future. In our opinion the development of chemical weed control is able to keep step with tolerance in the weeds, and will provide protection against more resistant weed species as well.

It must be repeatedly emphasized, however, that agrotechnical methods of weed control should also be increasingly utilized. An optimum or thicker than optimum plant stand provides protection against weed growth, and on areas without too many weeds may render chemical weed control superfluous, especially in the case of earlier varieties. Late varieties have the disadvantage that the summer weed flora makes the harvesting operations extremely difficult, particularly in cool, rainy summers. The reason why dwarf and semi-dwarf wheats are not widely grown at present is that they cannot be protected from weeds with a single application of herbicides.

KURUCZ, GY.: Efficient weed control in wheat "exclusively with chemicals" is impossible. Both research results and farm practice prove that high level wheat production can only be realized by the optimum application and co-ordination of cultural practices. The application of chemicals, however efficient, is only one of the factors of weed control. In wheat stands where the correct cultural practices are used chemical treatment is often unnecessary. High level wheat production is based on weed control carried out using agrotechnical methods supplemented by the application of chemicals. On areas where up-to-date cultural practices are applied in wheat production, and where crop rotation ensures that wheat is not sown after wheat more than twice, resistant weed species do not develop and spread. The results of investigations carried out in recent years prove unambiguously that bicultures give higher yields. With the present availability of chemicals a monoculture over a longer period is not a basic requirement even in maize. The concentration of maize production within any one farm to such an extent as to prevent reasonable crop rotation is not justified by national consumer demands. The price increase for industrial products, particularly chemicals, make it imperative that attention be paid to the efficiency and necessity of cultural practices.

KÜKEDI, E.: Before World War II crop rotation as well as careful soil cultivation and plant tending were the usual means of weed control in Hungary. Herbicides were only used on a very small area, almost as a sort of experiment. In spite of this, in properly managed large farms weeds caused no special trouble in wheat stands. Since harvesting took place at the stage of waxy ripeness, most of the weed seeds got into the sheaves and were later removed with them from the field. Threshing was carried out in the farmyard, where the majority of the weed seeds remained. It is thus understandable that in properly managed farms using crop rotation the wheat stands could be kept free from weeds. However, this was not always true of small farms. Weeds caused particularly great damage after World War II in 1947, when 32.5% of Hungarian wheat stands were overgrown by weeds. The losses caused by weeds in the four main cereals (wheat, rye, oats and barley) in that year amounted to 600 million forints. The spreading of the weeds was promoted by the combines themselves, as the bulk of the weed seeds was left on the wheat field and later worked into the soil. Under such conditions weed control in wheat could no longer be carried out with the traditional methods. The appearance of herbicides was then of great assistance. Research on herbicides started in Hungary in 1947, but they were not tested by the farms until 1954. Since they fulfilled the expectations the herbicides spread rapidly, and are used today on 1.1 million hectares, i.e. on 85% of the wheat area of Hungary. At the beginning herbicides containing 2,4-D and MCPA as active agent were mostly used in practice, but today many other herbicides, efficient even against resistant weed species, are available. The advantages of chemical weed control (elimination of spatial parasitism, reduction in the number of various pests, earlier and more uniform ripening, easier mechanical harvesting, etc.) have been proved in practice since 1954, but its disadvantages have also become apparent. Weed species sensitive to the herbicides have been eliminated by now in Hungary as elsewhere, but those resistant to certain herbicides have survived and spread. The most frequent of these are: monocotyledons: *Alopecurus myosuroides* Huds., *Apera spica venti* (L.) P. B., *Avena fatua* L., etc.; dicotyledons: *Anthemis arvensis* L., *Fumaria officinalis* L., *Galium aparine* L., *Lamium* spp., *Matricaria* spp., *Polygonum convolvulus* L., *Stellaria media* (L.) Cyr., *Veronica* spp. The following weed species, on the other hand, have been kept down considerably: *Agrostemma githago* L., *Centaurea cyanus* L., *Raphanus raphanistrum* L., *Sinapsis arvensis* L., etc. The transformation and restriction of the weed flora and the development of resistant weeds is characteristic not only of Hungary, but of all countries in the world where herbicides are regularly used. These experiences clearly show that the weeds cannot be destroyed with herbicides alone: their replacement is ensured by the weed seeds which fall to the ground on harvesting, by deficient soil cultivation, etc. The survival of weeds is promoted by the fact that their weeds maintain their germinative ability for a long time. For these reasons the repression of weeds can only be expected from the joint application of traditional weed killing methods and herbicides.

LÁNG, G.: Chemical weed control is only one of the possible ways of fighting weeds. A clear, weedless stand of cultivated plants can only be obtained by co-ordinating all the possible methods of weed control. A particularly important role is played by tillage and the correct succession of crops. Observations connected with the non-tillage method have shown that weed control based on chemicals alone is nowhere near as efficient as when combined with a proper tillage method. In the case of wheat the role of tillage is particularly important, since on soils which are suitably cultivated weedless stands can be ensured without chemical weed control.

LELLEY, J.: Owing to its adverse effect on the environment and to the increasing number of resistant weeds, chemical weed control has, to a certain extent, come to a dead-end. The correct crop rotation, efficient fertilizer application, soil preparation and sowing, and a proper spring stand density will ensure the desired absence of weeds. Chemical weed control is, in fact, only justified when a thinning of the stand occurs through no fault of the farm. Chemical weed control should be only an emergency measure, since everything can be attained without the application of herbicides provided the work is carried out efficiently and conscientiously. If minimum tillage or no tillage becomes general practice, then the application of chemicals will be unavoidable. In that case herbicides should be synthesized which destroy all plants without exception but decompose very quickly.

NAGY, B.: In my opinion the control of the resistant weed species developing in wheat stands with each type of herbicide can be achieved by the correct placement of wheat in the crop rotation, by developing herbicide combinations and by ensuring herbicide combinations and by ensuring herbicide rotation. Apart from this, I think it necessary to adopt any new chemical or other weed control methods in cereals as soon as possible.

PETRÓCZI, I.: Chemical weed control certainly develops a weed flora resistant to the chemicals applied. However, herbicide research and manufacture have solved these problems. Two preparations, Dikamin and Gabonil, have been introduced exclusively for large-scale winter wheat, both of which give good protection against resistant weeds when applied at a rate of 2.5—2.8 litre/ha. Dicuran, a preparation licensed for experimental purposes, also seems to give perfect protection against selected weeds.

I do not see any problem as regards herbicides; during, application, however, care must be taken to prevent any possible dispersion, so it is advisable to continue to use a block arrangement.

POGÁCSÁS, GY.: The possibilities of protection against resistant weed species developing in wheat stands can be summed up as follows: a) correct cultural practices, soils kept "black"; b) correct succession of plants (different crops have different dominance over, and tolerance to weeds, and different weed species prevail in the stands); c) based on the correct succession of crops a herbicide (hormone-herbicide) rotation should be established, and the herbicides applied should be changed every few years even when they contain the same active agent; d) there seems to be a need to study the reactions of different wheat varieties to various weed species (dominance over and tolerance to weeds).

ROMÁNY, P.: A resistant weed flora has not yet developed in Hungary over the sowing area of winter wheat, as it has, for example, in maize. This is probably due partly to the fact that wheat is not grown in a monoculture in Hungary, and partly to the fact that a resistant weed flora can only develop in wheat treated for several years with herbicides containing the same active agents. In the case of a wheat monoculture the chemicals applied should be varied in order to prevent the development of resistant weed species.

ROSTA, K.: In the course of the last few years a considerable change has occurred in the composition of the weed flora as a result of regular chemical weed control carried out in the wheat stands. This change has taken place in two directions: first, the number of weed species has been reduced, and secondly, certain previously important species are gaining ground owing to their resistance to herbicides (e.g. *Avena* spp., *Agropyron repens*, *Apera spica-venti*, *Bromus secalinus*, etc.).

I think that the most important task is to make regular cenological surveys in the wheat stands in order to obtain information about the changed composition of the weed flora and the extent of coverage by the individual species.

With a view to reducing the weed species resistant to the herbicides currently applied I think it necessary to elaborate appropriate agrotechnical protection methods, including primarily well planned crop rotation.

Apart from this, more efficient superselective herbicides should be applied even if this leads in time to the development of further resistant weed species.

TARJÁN, R.: On the basis of our own investigations and literary studies we propose the introduction of new efficient herbicides. As far as we are aware, physical or biological methods are not available at present.

TULCZ, I.: I have always regarded the chemical weed control of wheat as a partial solution, and laid great emphasis on soil cultivation and crop rotation as methods of weed killing. I think it highly important to bring about a uniform stand of adequate density, thereby checking the development of weeds. With increased harvesting capacity harvesting losses caused by weeds can be prevented.

If the other possibilities of protecting crops from weeds are utilized, the role of chemical weed control will be diminished.

As for the development of a resistant weed flora, I do not think this represents too great a danger in the case of wheat. We have been using two herbicides — Dikonirt and Dikotex — for fifteen years, and the resistant weed flora has not developed to such an extent as to cause much trouble.

The chemical sciences are expected to make still more rapid progress in the future. The beneficial effect of this is already felt in the continuous appearance of new herbicides.

Thus there is every hope that weed growth will not be a factor hindering the development of wheat production in the coming years.

UJVÁROSI, M.: In a very simple and abstract form it really does seem that as a response to chemical treatments a resistant weed flora develops, thus involving the danger that new herbicides will result in new resistant weed species, in a vicious circle.

A closer examination of the problem, however, reveals a different situation. Today well-managed farms which produce high yields are characterized by wheat stands either completely or almost free of weeds, where there can be no question of a resistant weed flora.

On page 6 of my book "Weed control" (Gyomirtás, Mezőgazdasági Kiadó, 1973) I gave the following oft-expressed opinion: "According to our present knowledge of the weed flora the maximum utilization of the agrotechnical possibilities currently available, together with the necessary chemical weed control, provides the freedom from weeds required for attaining large yields and also results in clean soil."

In farms where weedless or nearly weedless wheat fields are found the weed-seeds and underground vegetative organs of perennial plants have mostly been removed from the soil as a result of years of up-to-date cultural practices and chemization. This is why adequate chemical control carried out every year can keep the fields in such a weedless state.

It is now known by many experts that the up-to-date agrotechnical facilities of our day represent a very much greater weed-killing capacity than those available a few decades ago.

It is also known that the much higher number of plants per unit area is now in itself an important factor of weed control, since given a satisfactory development of wheat plants the weeds emerging in the stand are repressed or completely destroyed.

On those areas, on the other hand, where adequate soil cultivation is not always carried out at the right time, or where the chemical treatments are not always efficient, the stands are naturally overgrown by weeds even today.

Weeds are particularly abundant in places where the chemical weed control of the current year has only been partly successful. On areas not yet free of weeds many wheat fields are found where the chemical weed control has not been of the right quality, or has been inefficient for other reasons, and has destroyed only the more sensitive species of the weed flora, leaving behind the more or less resistant ones. These are usually the plots where seemingly resistant weed species develop or spread.

Where there is a regular use of identical or similiar herbicides, however, particularly in a monoculture lasting several years, certain weed species resistant to the herbicide concerned may in fact spread over a smaller or larger area. In Hungary, for example, hormone-based herbicides which primarily destroy dicotyledonous weeds have been used for more than fifteen years for weed control in cereals. Under their selective effect the monocotyledonous weeds have become dominant in some places, in wheat especially *Apera spicaventi*, lately *Avena fatua*, and here and there *Galium aparine*, *Anthemis*, *Matricaria* species, etc., which are resistant to these herbicides. Today we are in possession of herbicides which can successfully be used against these weeds as well. Unfortunately, the use of further herbicides either in combination or alone involves a cost increase, therefore in many places they are not used except where it is unavoidable. Efficient weed control requires well-trained experts to apply the available herbicides according to need.

It must not be forgotten that the weed plants which cause damage to wheat may attack other crops too, and can therefore be controlled throughout the crop rotation with other herbicides not used for wheat. Today a wide range of chemicals and their combinations are available to the experts for use at the optimum time and place to prevent resistant weeds from spreading. And if they have already spread, there are special herbicides available to destroy them — even though this involves additional costs.

It must be kept in mind, however, that with the present large-scale pattern of crop production certain weed species may spread at the same unbelievable rapid rate as some pathogens and fungal diseases do. To take steps against them in due time before they spread uncontrollably is also a responsibility of the experts.

To deal with the diversified ecological, biological and agrotechnical problems of weed killing is beyond our scope, as is a detailed discussion of the possibilities of chemical weed control. These subjects are dealt with in readily available books and papers. It can be seen from what has been said above that crop production today has special means of preventing resistant weed species from causing problems. Practice has proved that with the proper utilization of the possibilities available crops can be kept practically free of weeds.

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PÁL, GY.: **In Hungary the sowing area is 1.3 million ha for wheat and 1.4 million ha for maize: today wheat is more profitably grown in Hungary than maize because investments are higher in the latter. Considering the profitability of the two crops, the world market demand for wheat, the fact that wheat is used as a protein source in Hungary and that maize is not only a fodder plant but also the raw material of germ oil and liquid sugar production, will — in your opinion — the sowing area of wheat increase or decrease in the future?**

BALLA, L.: In Hungary the sowing area of winter wheat has been reduced and fixed at 1.3 million ha. Owing to an increase in the production of fodder crops and vegetables a further minor reduction may occur, but substantial changes cannot be expected.

BEKE, F.: The production area of maize will decrease or stagnate if the cost levels increase or remain unchanged. Competition between the two species is always influenced by production costs and profits. Even if new technological procedures bring about new means of utilisation (maize germ oil, starch, invert sugar), it is still the production costs that will decide how the ratio of maize and wheat production should change.

BELEA, A.: A further slight decrease in the wheat sowing area should be expected in Hungary. The main reason is the utilization of areas unsuitable for wheat production (hilly, mountainous regions) for more useful purposes. New roads, housing estates and industrial areas also reduce the sowing area of bread-grains. On the other hand, the higher bread consumption involved with the population increase, and the growing requirements for reserves, exports and assistance programmes must also be taken into consideration. Therefore, in order to ensure a steady supply of bread the decrease in the sowing area must be coupled with a proportionate increase in yield.

BÓCZ, E.: Maize will continue to exceed wheat as regards yield potential. By increasing the yield in both crops the maize requirements might be covered with a reduced sowing area. In my opinion the sowing area of wheat should be increased. Areas less suitable for maize production will be given over to wheat production. Soils with comparatively poor natural conditions can in fact be better utilized for wheat.

Csontos, M.: This is a question of economic policy. The percentage distribution of crops on a national scale is determined by economic regulators and according to central expectations.

Some increase in the wheat area might be possible in the future, but only at the expense of crops other than maize.

Erdei, P.: The present sowing areas of wheat and maize have been fixed mainly by the pressure of economic and operative conditions. This ratio was influenced very little, if at all, by the production overheads. Since the sowing structure proportion has not undergone any substantial change for some years, in spite of the fact that from a mercantile point of view they have advantages both together and separately, the situation is not likely to change in the future.

Kiss, Á.: Wheat as a source of protein will maintain its leading role for a long time. Moreover, in the new wheat varieties the breeders will be able to increase the protein content by 1—3% while the yielding ability remains unchanged, or possibly shows an increase.

By increasing the protein content the amount of lysine contained in the protein may also be increased. Exceptions to the correlation have already appeared in many hybrids.

Considering the present technology and the difficulties in transportation maize can hardly be regarded as an oil plant (germ oil). As a fodder plant it will continue to play a leading role. Maize will become a particularly valuable fodder crop if breeders succeed in fixing a high lysine content in the normal type maize grain, while maintaining or possibly increasing the yielding ability.

Attempts to breed for high protein and lysine contents and high yielding ability in maize have not been successful so far, though an increase in the lysine content and yielding ability have been achieved at a low protein level.

Koltay, Á.: The wheat area of Hungary has become constant at about 1.3 million ha in the past decade. This is a satisfactory size which need not be either increased or reduced. A further increase in the yield average is expected; a 40 q/ha national average can certainly be reckoned with in the future, which means around 5 million tons of wheat. If a total yield of this order can be attained, a considerable volume can be exported after fulfilling domestic demands.

Kurucz, Gy.: The wheat area in Hungary shows a general tendency to decrease, to an extent depending on the intensification of crop production, and on the increase in the fodder requirements for livestock. In spite of this, the following decades will be characterized by changes in the areas and soils used for wheat production rather than by a reduction in the wheat area. Cost-intensive crops with a high production value (vegetables, sugarbeet, maize, industrial plants, etc.) can be profitably grown only in fertile soils. With the present farm size there is more than one type of soil in almost all farms, so that crops with higher production values can be grown in better soils. This means that a larger proportion of wheat will be grown in soils of relatively poor fertility (alkali, alkalescent, meadow and forest soils, poor sand, etc.). In more fertile soils (particularly chernozem, meadow, black sand, etc.) the proportion of wheat production will be determined by the needs of crop rotation. This tendency will slow down the rate at which the average wheat yields per unit area increase. The demand for varieties able to produce higher yields in less fertile soils by adapting themselves to the unfavourable local conditions will increase. Unfortunately, at present there is no variety testing station in Hungary characteristic of regions with unfavourable conditions, so it is impossible to test the adaptability of new varieties to comparatively poor soil conditions.

Bezostaya, and more especially Jubileinaya, have the highly valuable property of being adaptable to poorer soil conditions and giving reliable uniform yields. I do not want to go into details about the more favourable territorial location of wheat breeding which previously existed in Hungary, but I think it is justifiable to test the breeding material on a wider range of soil conditions, and to aim at the development of varieties giving larger yields under poorer soil conditions. All in all, instead of reducing the sowing area of wheat I suggest transferring the wheat production in Hungary to areas with less favourable soil conditions, which implies taking the poorer production conditions into consideration in breeding.

Láng, G.: The wheat area in Hungary will not change significantly in the future. In order to prove this statement we would have to deal not only with plant production and biological considerations, but also with important questions of production management, economics, marketing, etc. In agriculture it would be a great mistake to follow the price fluctuations on the world market with a quick and thorough adjustment of the production structure. Such structural changes would be very expensive, and the costs would exceed the advantages originating from the momentary price relations.

LELLEY, J.: The optimum ratio of the wheat and maize areas should be established in accordance with the interests of the national economy and the possibility of export. Wheat growing can be 100% mechanized and the world market demand for wheat is constantly increasing, so I think the wheat production area will have to be increased to a reasonable extent sooner or later at the expense of the maize area. Before this can be done, however, the confusion now experienced with regard to wheat monocultures must be cleared up. An increase in the sowing area would only be rational if the average yield did not decrease. Wheat areas will probably continue to increase all over the world, since wheat is much more suitable for the nutrition of the increasing population than maize. It will not take long to arrive at the point where the area of bread grain must be increased even at the expense of livestock farming.

NAGY, B.: In my opinion, the relative areas of wheat and maize production will not change even in the long run, since maize, as a C-3 type cereal with unbelievable genetic and biological plasticity, is our most reliable fodder and industrial plant, the production, mechanization and chemization of which offer great possibilities.

POGÁCSÁS, GY.: In Hungary the two crops occupying the largest sowing area are maize harvested for grain, with 1.4, and wheat, with 1.3 million ha.

In the statistical data the yield of maize is shown as being larger than it actually is, because part of the silage maize is harvested as a grain crop, and this grain yield is included with that for the maize area sown on 31st May.

The maize sowing area cannot be increased any more in Hungary, because the best growing sites must be reserved for industrial plants, vegetables and other priority crops. All the good land has been occupied by maize. Wheat production has been confined to poorer quality land, as wheat can be grown profitably on poorer soils where maize does not yield acceptable results. The fifth five-year plan (1976—1980) reckons with the present sowing area, so there is nothing in the economic policy, the site conditions, or the relative profitability of maize and wheat to indicate that any substantial change in the sowing areas of these two crops is to be expected. After an outstandingly good maize crop or an outstandingly high wheat yield the area of maize or wheat may increase or decrease by several tens of thousands of hectares.

ROMÁNY, P.: During the period of the fourth five-year plan (1971—75) the sowing area of wheat became fixed at 1.3 million ha. The increase in the maize sowing area took place at the expense of other crops. I am of the opinion that the wheat area will not change in the future either. The present area is necessary to meet the demands of the national economy. Inasmuch as the wheat yield average continues to increase, the sowing area could be proportionally reduced. A further increase in the sowing area is, however, impeded by the limited number of possible pre-crops.

SZALAY, D.: The potential yielding ability of the new intensive winter wheat varieties is near to the grain production of maize hybrids. Wheat is mainly consumed as a human foodstuff, though due to its higher, biologically more valuable protein content it is also superior to maize as fodder. Its utilisation value is also expressed by its higher world market price. The production cost is lower for wheat than for maize. The most difficult problem facing farms at present is the autumn harvesting peak. Thus, it is not by chance that the sowing area of wheat has increased in recent years (from 1.015 million ha in 1970 to about 1.3 million ha in 1975). This renders a further increase in the joint share of bread and fodder wheats at the expense of fodder crops (maize, barley) probable.

TARJÁN, R. Great efforts are being made to alter the nutritional habits in Hungary. One of the most important objectives is the modernization of ancient nutritional habits and their adaptation to our present way of life. We should like to achieve a decrease in the per capita cereal consumption for the population of Hungary, similar to the conditions in the developed industrial countries. Certain results have already been attained in consumption habits, but not in shopping habits. According to our investigations people buy substantially more cereals (bread, pastries, pasta, etc.) than they actually consume. Consequently, if we consider the shopping habits, the home "requirements" in Hungary have not changed a great deal, nor has the demand of the population decreased very much. It is possible that effective propaganda, and especially changes in the output of the baking industry (or perhaps the modification of price subsidies?) might succeed in bringing shopping habits closer to consumption habits. This cannot, however, be expected in the near future, so the population's demand for wheat and foodstuffs made from wheat will hardly change in the coming years.

TULCZ, I.: I do not think that the sowing area of wheat will be reduced in the following years. Besides the profitability of wheat production other factors also play a role in maintaining its present level. It is in wheat production that mechanization is best solved, and harvesting can be carried out with the lowest possible yield loss using the available means. From a management point of view it is also important that wheat harvesting takes place during the most favourable period of the summer, since under favourable weather conditions the long days render a higher intensity of work possible, as opposed to the rainy, cold period occurring during the harvesting period of crops ripening in autumn.

I expect the sowing area of maize to decrease during the next few years, but without a simultaneous increase in the sowing area of wheat. This can be explained by the fact that the sowing area of wheat has generally attained the uppermost limit beyond which various problems arise. It is true that wheat is more profitable than maize but for a given unit area wheat produces a relatively moderate profit. So in my opinion the areas released from maize growing will be used for crops judged more profitable than wheat. The area of roughage should be substantially increased due to the planned quantitative and qualitative improvement of cattle breeding.

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PÁL, GY.: **In Hungary, as in many other countries of the world, wheat is grown after wheat in a monoculture over a large area, and this area is expected to grow in the future. Do you think that the lower yields and the large annual yield fluctuations resulting from the monoculture can be eliminated by elaborating new cultural practices and plant protection techniques, or only by producing new wheat varieties?**

BALLA, L.: Earliness, short straw and complex resistance provide protection against the adverse effects of a monoculture. With short-action (1—2 years) maize herbicides wheat may be produced for two years on the same area; in this way the effect of the monoculture can be reduced to a minimum.

BEKE, F.: It will certainly be possible to lessen the disadvantages of a wheat monoculture. Apart from the role of pests and pathogens other factors such as the accumulation of allelopathic substances, the exhaustion of microelements or a slower accumulation of these elements due to changes in the fauna and flora of the soil, structural changes in the soil due to similar causes, varietal responses, etc. are all extremely important. It is almost impossible to prevent the adverse effects of all the above factors year by year. A partial monoculture will probably be maintained or may even spread, but an overall monoculture would be dangerous. After some time a monoculture results in a stagnant yield level, and it is debatable whether it is more economical to maintain it or to replace it by a bi- or polyculture.

BÓCZ, E.: The area of wheat monoculture must not be increased until the efficient control of fungal diseases is solved. Several years ago the production of wheat after wheat was still more or less acceptable. Today this order of sowing causes serious yield losses. My previously expressed views imply the breakup of the sowing structure and the necessity of successive cereal production. The problem can be partly solved by growing other cereals, particularly winter barley, on a larger area in the future. A perfect solution can only be attained by the development of further resistant varieties. Triticale may be of considerable help due to the resistance of rye.

CSONTOS, M.: In my opinion the area of crop production in a monoculture is not increasing in Hungary. The problems it causes are not solved by new cultural practices and plant protection techniques; new, resistant wheat varieties are absolutely necessary.

ERDEI, P.: Provided the agrotechnical rules are observed wheat can be grown in the same place on two successive occasions without any danger of yield reduction. Under arid conditions a monoculture can hardly be maintained over a longer period. Neither cultural practices, nor plant protection, nor the variety can solve the problem alone.

The failure of wheat in a monoculture is closely connected with the agrometeorological conditions during the period between the two wheat crops, the microbial activity of the soil related to this, the specific biochemistry of the decomposition of straw, etc. Although plant protection, cultural practices (soil cultivation, fertilization, irrigation) and the diseases resistance of the variety may lengthen to some extent the period during which wheat can be grown in a monoculture, they cannot make it permanent.

KÁDÁR, A.: In my opinion permanent monocultures should be avoided, but I think that wheat varieties tolerant to 2—3 years of monoculture are important, because during this period plant pests and pathogens can be controlled.

KISS, Á.: Yield losses resulting from monocultures are not likely to be eliminated by the new cultural practices and plant protection techniques. Crop rotation is indispensable in the case of wheat. It may perhaps be possible to incorporate certain properties characteristic of rye in the new wheat varieties, but this can only be attained as the result of lengthy genetic and breeding work. It may happen, however, that together with these properties many other unfavourable characters coupled with them will also be incorporated into the wheat. These could only be removed by complicated genetic (mutational), aneuploid breeding methods, involving lengthy selection. Crop rotation applied at the appropriate time is a much simpler method, from which results can be expected much sooner.

In my opinion all three methods should be applied and studied. Much is at stake — the supplying of the population with bread — so it is worth all our efforts.

KOLTAY, Á.: With the present plant growing technologies a periodical wheat monoculture is unavoidable in the farms and must be reckoned with in the future as well.

The depression cause by a monoculture in wheat production is mainly due to the upsetting of the nutrient balance, the overgrowth of certain weed species and the appearance of insects and various fungal diseases.

The monoculture tolerance of the wheat varieties is highly varied. According to our investigations there are derivates that have shown only a moderate depression in permanent monoculture.

Besides choosing the right variety an efficient means of reducing the depression caused by a monoculture is an adequate rate of fertilization and a proper nutrient ratio. According to the results of our investigations, without an immediate replacement of nutrients the yield may be reduced to a minimum by the third year of the monoculture. On the other hand, with adequate soil cultivation and NPK application and by carrying out plant protection operations in due time the yielding ability of the varieties can be maintained. In the very dry year of 1975—76 the varieties most tolerant to a monoculture gave a 60—70 q/ha grain yield in the ninth year of the monoculture.

KURUCZ, GY.: Growing wheat in a monoculture is, in my opinion, mainly justified under poorer soil conditions. With an adequate change of species or variety the yield averages of cereals grown in such soils do not substantially decrease in 2—3 years of monoculture. On alkali soils a 60—65% proportion of cereal production will be unavoidable in the future. I think that on these areas the problems arising from the monocultural production of wheat can be solved by the application of rational cultural practices (including the regular burning of the stubble left behind after wheats grown in a monoculture) and by the development of varieties whose yields will not decrease in the second, or even third year. I cannot see how the adverse effects of monocultural production could be eliminated by the improvement of plant protection, especially considering the financial aspects.

KÜKEDI, E.: Cereals are used as pre-crops on more than 25% of the 1.3 million ha winter wheat area of Hungary, but there are farms where this proportion is as high as 30—40%. A similar situation is found in the neighbouring countries, Czechoslovakia, Yugoslavia and Rumania. In Austria and the German Federal Republic the proportion of cereal pre-crops has increased, particularly in the last twenty years, and there are farms where wheat is grown in a monoculture. In the dry regions of the United States wheat production in a monoculture is also efficient. According to the results of experiments at Martonvásár (carried out by Győrffy) growing wheat in a monoculture involved the greatest risk in the third year, because by then the foot diseases (*Cercosporella herpotrichoides* Fron., *Fusarium* spp., *Helminthosporium sativum* PK et B., *Ophiobolus graminis* Sacc.) had assumed such serious proportions that the yields fell, mainly due to these diseases, from 38.8 q in 1961 to 14.9 q. Later an equilibrium was set up, and the yield averages depended decisively on the weather. In years with dry springs there was not usually any great difference in yield between wheats grown in crop rotation and those produced in a monoculture; on the other hand, in years when the spring was favourable to fungal diseases the yield averages declined sharply. Since neither weed damage nor harvesting losses occurred in the experiments, the crop failure was mostly due to fungal infection. In 1970, for example when the spring was favourable to fungal diseases, the yield of the variety Bezostaya 1 was 12.5 q/ha.

The same variety grown using the same cultural practices yielded 41.3 q/ha in 1971, a year with a dry spring. The situation was the same in the farms. In 1970 and 1975, when the spring was rainy, fungi caused serious damage, especially to wheats sown after cereal pre-crops. In 1976, on the other hand, when an unusual drought occurred in the spring, an unexpectedly high yield was harvested, mainly due to the absence of fungal infection.

Yield fluctuations cannot be prevented simply by the use of resistant varieties. In the near future breeders are not likely to produce a variety resistant to all the major fungal diseases occurring in Hungary. To develop a variety tolerants to *Ophiobulus* *graminis* Sacc. will be a particularly difficult undertaking. At the same time, wheats resistant to *Cercosporella herpotrichoides* Fron., and even to *Fusarium* spp., are already at our disposal. Strong rooted varieties generally tolerates being grown in a monoculture and regenerate well. Bezostaya 1, Avrora and their derivatives, on the other hand, are particularly susceptible to foot diseases.

Besides growing resistant varieties, great assistance is offered by the proper cultural practices, including plant protection. Extremely careful soil preparation, optimum sowing time, balanced NPK nutrition, etc. deprive the pathogens of the conditions necessary for epidemics.

This method of protection is not, however, sufficient to maintain the yield level in varieties susceptible to diseases. Fortunately, there are already licensed fungicides suitable for controlling fungal pathogens. According to the experiences gained at home and abroad, in years when the spring is not too rainy any of the following fungicides can be successfully used against *Erysiphe graminis:* Afugan, Bayleton, Fundazol or Benomyl, Persulon and Saprol. These fungicides provide satisfactory protection when sprayed on two occasions (at stages G and M). Fundazol (Benomyl), Derosal and Cercobin M are efficient fungicides against *Cercosporella herpotrichoides.* Infection of spikes by *Fusarium* and powdery mildew, and the spike diseases of wheat in general, can also be controlled at stage N with Fundazol and Tilt. In experiments performed at Martonvásár the yield of wheat was increased by 7—9% compared to the untreated control by using the latter fungicides.

On the basis of the experimental results and practical experience obtained so far, it can be established that cereal pre-crops or wheat sown after wheat do not cause yield losses for one year if agrotechnical discipline and the instructions for growing wheat after a cereal pre-crop (change of variety, use of varities tolerant to a monoculture, thorough soil cultivation, not too early and not too dense sowing, balanced NPK nutrition, chemical weed control, etc.) are strictly observed. If in addition to this increased care is taken to prevent damage caused by fungal and animal pests, yield deviations can be greatly reduced. The risk involved in growing wheat in a monoculture is, however, greater, being more closely related to the weather and fungal infection. It is possible to control pests and a monoculture can be successful, but in years with rainy springs the economic efficiency may be questionable owing to the increased costs of plant protection.

LÁNG, G.: A wheat monoculture in the strict sense of the word has not developed in Hungary. Growing wheat after wheat on a single occasion does not generally result in any reduction of yield; on the contrary, larger yields are often obtained than when wheat is sown after maize. With the present crop ratios there is no need to increase the risk by growing wheat successively in a monoculture. In cases where the farm is compelled to sow wheat in the third successive year in the same field, the resistance of the variety as well as plant protection assume increased importance.

LELLEY, J.: I have pointed out on several occasions that the causes of the yield-reducing effect of growing wheat in a monoculture ought to be examined more systematically and efficiently, as it is a highly important question which must be settled very shortly, otherwise the total volume of plant food produced in the world will hardly be enough to sustain the human race within a couple of decades.

If the yield-reducing effect of the monoculture were primarily a pathological question, it could be solved by breeding. However, in my opinion it is a much more complex problem. We know hardly anything about the inhibitory effect of stubble on germination, and the importance of the trace elements has not been clarified either. Nor has the question of whether deep or shallow cultivation can better compensate the harmful effect of the monoculture been studied in sufficient detail. Practically nothing is known about the monoculture tolerance of different cultivars.

It would be desirable to make special efforts — both financial and intellectual — to analyse this problem and clear up all its details. If only a fraction of the energy spent on fertilization experiments were concentrated on this problem, we would be much closer to a solution. Monoculture tolerance is an important task for breeders and ought to be thoroughly studied by a team specialized for this purpose.

The question of growing wheat in a monoculture ought to be ranked with the most important research tasks. Totally new possibilities would be offered for wheat production if this so-far neglected field were explored, and an answer given to the question of whether wheat can be sown after wheat for years without any decrease in yield.

MANNINGER, G. A.: Wheat does not readily tolerate being grown in a monoculture, especially near the borders of Hungary. According to the results of glass- and net-trap investigations the unfavourable consequences of a monoculture already appear in the first few years. Of the pests which cause damage to wheat, *Zabrus tenebrioides* and *Sitodiplozis mosellana* particularly favour the monoculture. The variety has little influence on the extent of damage caused by these pets. Another interesting thing is that the damage caused by corn bugs is quite independent of whether the crops are grown in rotation or in a monoculture. In this case there may be, and usually are, differences in susceptibility between the varieties. However, a higher proportion of damage only occurs every thirty years or so.

NAGY, B.: I have long been convinced that with the wheat varieties grown at present the monoculture of wheat is unrealizable, primarily for epidemiological and production hygiene reasons.

No suitable methods or chemicals are available for soil disinfection. It is therefore necessary to solve the production of wheat by some kind of shift cultivation method until wheat varieties with the highest possible resistance to soil fungi are produced by the breeders. The pre-crop must naturally be adapted to the local conditions and production structure, but great care must be taken that the decompostion time of the herbicides applied for chemical weed control should be shorter than the vegetative period of the pre-crop.

PETRÓCZI, I.: In my opinion, wheat need not and will not be grown in a monoculture for more than 2—3 successive years. With proper cultural practices and up-to-date plant protection technology, yield fluctuations can be prevented. Plant protection inputs for wheat are low at present compared to other crops. The new seed dressing technologies do not substantially increase the costs, so the economic efficiency of wheat growing will remain high.

POGÁCSÁS, GY.: In Hungary wheat cannot be successfully grown in a monoculture. Farms might occasionally be compelled to sow wheat after wheat on a small percentage of their sowing area; with proper cultural practices, change of variety and chemical treatments this can be safely done without a loss in yield. On amalgamating fields I found that in those parts where wheat was grown for 3 years its yield fell drastically in spite of careful cultural practices. Growing wheat for three years on the same plot is not advisable, nor is it necessary in Hungary.

ROMÁNY, P.: In Hungary wheat is hardly grown in monoculture in practice, since growing in two successive years — mainly after papilionaceous pre-crops — cannot be called a monoculture. A monoculture has many adverse consequences which should be avoided at all costs. In my opinion the adverse effect of growing wheat in a monoculture cannot be completely prevented either by introducing new varieties or by using expensive plant protection methods. The plant growing structure in Hungary and the fulfilment of the requirements of the national economy do not make it necessary to grow wheat in a monoculture on large areas. It is thus important to establish conditions of farm management and mechanization which will help to prevent the enforced application of a monoculture.

ROSTA, K.: In my opinion, the dangers arising from growing wheat in a monoculture are likely to appear within 3—4 years. Even using the most careful cultural practices, pathogens, pests, and weeds resistant to herbicides may occur. These factors may cause a reduction or fluctuation in the yield. More intensive disease control, however, increases the production costs.

In discussing the problem one must also take it into consideration that in Hungary the time between harvesting one wheat crop and sowing the next is relatively short, and is insufficient for the decomposition of stubble and roots and the preparation of the required seed-bed.

I think that these difficulties of monoculture production can be decreased by improving cultural practices, applying up-to-date plant protection techniques and developing readily adaptable varieties resistant to disease. However, considering the Hungarian conditions, I do not think it practicable to grow wheat for more than 2—3 successive years.

SARKADI, J.—BALLA, H.: The first thing to decide is whether the yield of wheats grown in a monoculture is really always lower than the wheat yields produced in crop rotation, and whether this reduction in yield is a necessary consequence of monoculture.

It is a well known fact that the unfavourable effects of growing wheat in a monoculture are due to an insufficient nutrient supply, prevalence of weeds and fungal diseases and mass occurrence of certain soil-borne pathogens, nematodes and insects.

At the present level of crop production in Hungary there can be no problem in providing an adequate nutrient supply. There are numerous literary data on long-term experiments which prove that with the right method of nutrition wheats have been successfully grown in a monoculture for several decades. In the classical long-term experiment at Rothamsted the yield of wheat well supplied with nutrients did not decrease for 60 years (1852—1911), while in the unfertilized plots, or where the fertilization was one-sided the yield was reduced by 30% compared to the first year of the experiment. However, in the subsequent 20 years pests and pathogens appeared and cut the yields down sharply. The yield level remained similarly constant at the experimental sites of the Wooster University, Ohio, and of Columbia University, in wheat monoculture experiments carried on over 30 and 40 years, respectively.

From the partial results of our own long-term nutrition experiments we too have come to the conclusion that the yield of wheat grown in a temporary monoculture does not necessarily decrease. We carried out experiments over 8 years, from 1962 to 1969, at three sites: at Pesthidegkút on a slightly acid loamy brown forest soil; at Nagykálló, on a slightly acid sandy brown forest soil; and at Nagyhörcsög, on a lime-coated chernozem. In these experiments we were able to make a comparison between the yields of wheats grown in a two-year rotation of maize and wheat, and of those grown in a monoculture. The wheat varieties examined were Bezostaya 1 and 4. The succession of plants was such that the yields given in the 3rd and 7th years of the wheat monoculture could be compared with those obtained from wheat grown after maize (Mv 40). At Pesthidegkút and Nagyhörcsög, where the soil was successfully kept free of weeds and the plant stand was healthy, the yield of wheat was not lower in a monoculture than in crop rotation, and did not decrease with time. At Nagykálló, on the other hand, the soil of wheat sown in a monoculture became overgrown by weeds, and for this reason, in crop rotation the yield was more than 10 q/ha higher than in the monoculture. Weed growth led thus to yield reduction in later years.

Besides these three sites the effect of a four-year wheat monoculture (1965—1969) was studied in 4 experiments at Martonvásár with the variety Bezostaya 1. In these experiments as in those at Pesthidegkút and Nagykálló, the wheat yields were steady, apart from the annual fluctuations.

In our opinion the most serious problems in a wheat monoculture are thus caused by weeds, and by vegetal and animal pests. These can be controlled by up-to-date methods of plant protection and with the correct cultural practices. It is another matter that chemical plant protection is still rather expensive, so that the wider introduction of a wheat monoculture would require the reduction of plant protection costs and the use of varieties more resistant to disease.

Szalay, D.: Wheat sown after wheat is unavoidable in most Hungarian farms. The adverse effects of a temporary (two or three year) monoculture can be prevented primarily by agrotechnical and plant protection measures. Differences between the wheat varieties in their tolerance to a monoculture, however, make it necessary to carry out investigations in this respect. The cultivation of varieties tolerant to a monoculture may further decrease the harmful effects.

Tulcz, I.: The area of wheat monoculture in Hungary is not likely to increase in the near future. The well managed farms are tending to reduce the area of wheat grown in a monoculture. High yielding early maize varieties can be reckoned with as pre-crops for medium early wheat. Sunflower has also become a pre-crop for wheat since defoliation has been included in production technology. In this way the sunflower is removed earlier, and the stalk remnants can be chopped up much more efficiently. With this technology — as proved by the first few years — good wheat yields can be obtained after sunflower. With a change in the sowing time essential improvements have recently been observed in the monocultures. Namely, wheat grown after a wheat crop sown in the second half of October was not affected by various fungal diseases as seriously as that sown at the end of September, or the beginning of October in previous years. This suggests that efficient solutions concerning wheat production in a monoculture can also be found in the field of cultural practices.

Differences between the varieties in tolerance to a monoculture have been demonstrated in practice.

I think that in eliminating yield reductions caused by the monoculture plant protection plays an important role, which will increase still more in the coming years, provided the aerial capacity available for plant protection increases.

All in all, the area of wheat monoculture should be decreased, and on those areas where a monoculture is maintained every effort should be made to reduce its harmful effects as much as possible.

*

LECTIONES

HYBRIDISATION IN WHEAT BREEDING*

1. *How it all began*

In 1694 Camerarius discovered the nature of sexual propagation in the plant kingdom. The first spontaneous hybrid was described by Mather in 1716 on maize and the first artificial hybrid was produced by Fairchild in 1717 on carnation. Koelreuter, however, who published a paper entitled "Preliminary report of some experiments and observations concerning sex in plants" on September 1st 1761, is rightfully regarded as having carried out the first scientific and practical research on hybrids. This paper was followed in 1763, 1764 and 1766 by three more papers on the same subject, in which Koelreuter summarised the results of 136 plant hybridisation experiments (ROBERTS 1965).

Koelreuter made minute, systematic notes on the traits and properties of the parent plants and on the deviations observed in their hybrids. In numerous crosses he noticed a hybrid effect which significantly exceeded the vitality of the parents and which was inversely proportional to the degree of relationship between the parents in the cross. And since the morphology of the flowers and the way in which the plants are pollinated and fertilised gives evidence that nature favours cross pollination and fertilisation, Koelreuter came to the conclusion that the hybrid effect is of particular importance in evolution.

Both of Koelreuter's observations stood the test of time, and the evolutionary significance of the diversity of organisms was confirmed and provided with a theoretical basis by control experiments, the most convincing of which were Darwin's epoch-making experiments on plant hybridisation.

Having made a thorough study of the knowledge gained by earlier investigators of the organic world, and having compared this knowledge with the results of his own comprehensive plant experiments, DARWIN (1895) wrote his third monumental work "The effects of cross and self fertilisation in the vegetable kingdom", the first edition of which was published in 1876. In setting up his experiments he concentrated on plants rather than animals, since it was possible to raise large populations of plants and to investigate the effect of both self and cross pollination. On analysing the reasons for his final conclusion that "cross-fertilisation is generally beneficial and self-fertilisation injurious", Darwin states that in the case of pollination between plants which are not nearly related the sexual elements developed under different environments are united during fertilisation, while the unfavourable effect of inbreeding is due to the lack of differentiation between the sexual elements of flowers on the same plant.

The experience gained by plant breeders over the centuries shows that by means of hybridisation a union between the favourable characters of the parental partners taking part in the cross can be achieved in the progeny in a single new variety, genetic variability can be developed, and heterosis or hybrid vigour can be utilised.

* Inaugural lecture, delivered on March 1st 1977 as corresponding member of the Hungarian Academy of Sciences, elected at the General Assembly in May 1976.

2. The zenith — with illustrations

Of all cultivated plants, that on which the most intensive breeding has been carried out is wheat. According to VAVILOV (1935), wheat registers the current state of plant breeding theory, i.e. plant genetics, since numerous chapters of plant genetics have literally been "written" on wheat. If Vavilov is right, wheat breeding is the touchstone of genetics, since genetic theories can only be regarded as correct if they serve as the scientific basis for successful variety production. The creative work of three researchers, Lukyanenko, Borlaug and Remeslo, who represent the zenith of modern wheat breeding, and whose winter and spring wheat varieties are currently cultivated on the largest areas all over the world, lends itself as an illustration of this.

a) As he wrote in 1966, Lukyanenko based his breeding on the Michurin theory of intraspecific crosses between geographically and ecologically remote forms and on the method of repeatedly crossing young hybrid varieties with other, established varieties. The hybrids produced from geographically and ecologically remote forms are more viable, more plastic and have a wide genetic basis (LUKYANENKO 1966).

b) The raising and testing of two generations of the full breeding material each year in completely different surroundings, which was pioneered on a world scale by Borlaug and his co-workers, has made a fundamental contribution to the success of the Mexican CIMMYT programme. This raising and testing programme covers the whole of the breeding stock, from the youngest, segregating hybrid progeny to provisional varieties. One generation is sown in the autumn, generally in September, in the north, in Sonora province, which borders on the USA, at a latitude of 28°, near the sea, a few metres above sea level. Seed selected as required from this first generation is sown as the second generation in the middle of May near Toluca, not far from the capital, at a latitude of 18°, about 1200 km south of Sonora by air and 2800 metres above sea level. The breeding stock is thus transported to and fro between Sonora and Toluca each year. Meanwhile, the raising and testing of two generations a year in two completely different environments results in the production of spring wheat varieties with very broad adaptability and practically neutral to daylength and sowing time, while the breeding process is also speeded up (BORLAUG 1968).

c) In Remeslo's programme at Mironovka the principal method by which initial stock is produced is autumnisation, the repeated sowing of spring wheats at intervals during the autumn. Winter or spring habit is a hereditary character in a number of *Gramineae*, including wheat, and the heredity is attributed to 1, 2, 3 or more genes. During autumnisation a spring wheat form, which does not require a temperature near the freezing point and shortening daylength in order to flower, is sown in the autumn for consecutive generations, whereby its genetic constitution is changed to such an extent that exposure to a temperature near the freezing point and shortening daylength become necessary if flowering is to be induced. A genetically determined spring character is thus changed so as to transmit the acquired winter character (LYSENKO 1958).

The basis for Remeslo's best-known and most widely cultivated winter wheat, Mironovskaya 808, was the autumnisation of Artemovka spring wheat, begun in 1950. In 1963, the year it was state qualified, it was sown on 72,000 ha, while in 1967 the sowing area was already 6.2 million ha. The latest Mironovka varieties, Jubileinaya 50, Ilichevka, etc., are partly of hybrid origin, but one of the partners in the cross is an autumnised wheat (REMESLO 1972).

d) What the illustrations teach us

d_1. Intraspecific hybridisation combined with selection offers an incomparably wider range of possibilities to the wheat breeder even today than any other method, so it can justly be regarded as the most efficient wheat breeding method yet discovered.

d_2. The raising of breeding stock under diverse conditions is an effective method for developing adaptation and vitality.

d_3. The world-wide success of the Mironovka winter wheat breeding programme, based on autumnisation, and in particular of Mironovskaya 808, which was selected from an autumnised wheat population and is cultivated over many millions of hectares, has caused MAKSIMCHUK (1963) to regard autumnisation as a breeding method which can vie with hybridisation.

3. *Wheat research at Martonvásár*

a) When combine harvesting became more and more general in Hungarian agriculture in the middle of the century, the deficiency in the stiffness of straw in the Bánkúti wheats became more and more conspicuous and obstructed the intensive development of wheat production by making not only combine harvesting, but also up-to-date artificial fertilisation almost impossible. Since no intensive wheat varieties were available from Hungarian breeders, we instigated the testing in Hungary of foreign intensive wheat varieties as a temporary measure until suitable varieties should be produced in Hungary. The foreign wheat varieties, especially Bezostaya, bred at Krasnodar, to which I drew the attention of the agricultural administration in my report on a study trip to Southern Ukraine and Kuban in 1954, made a fundamental contribution to the doubling of the Hungarian wheat yields by the beginning of the nineteen seventies. This was the subject of a pamphlet I was requested to write in 1960, which bore the title "How can we double our wheat yields?" (RAJKI 1960). At that time I was accused by more than one colleague, and also in official places, of having introduced into the title of the pamphlet an aim that was irresponsible, illusory and ridiculous . . . What a good job my opponents were not proved right! And as usually happens, when Hungarian agriculture achieved this "irresponsible, illusory and ridiculous" aim, little more than ten years later, most of my opponents took all the credit for themselves. C'est la vie!

The introduction of Bezostaya not only resulted in a doubling of the Hungarian wheat yields, but also granted a breathing space for the establishment and development of intensive wheat breeding at Martonvásár, the first results of which appeared at the end of the sixties.

b) In the Martonvásár winter wheat breeding programme, which started from scratch, the first crosses were carried out by my wife and me in the late spring of 1956. Following in the footsteps of László Baross, who used the autumnisation of the Canadian wheat Marquis in the breeding of the world famous Bánkúti wheats, our primary aim was to produce a winter wheat which would excel the standard Bánkúti 1201. The following anecdote may serve to give some idea of the enormity of the task which faced us. At the end of the fifties, not long after my family and I had moved into the small manor house, a bust of László Baross, which the sculptor had set up in the park with its back towards our flat, was unveiled. On this occasion an elderly wheat breeder jokingly remarked that the Rajki's would not produce a better wheat than the standard, Bánkúti, until Baross's bust turned to face the small manor house.

By 1957 our present aim had crystallised: to produce a good quality, winter hardy, drought resistant winter wheat, responsive to intensive conditions, suitable for mechanical harvesting, resistant to disease and with high yielding ability.

At Martonvásár, as elsewhere, the main method for producing basic breeding stock is intraspecific hybridisation, but the methods also include autumnisation, while remote hybridisation and mutation are used in a parallel programme. Apart from, and to a certain extent instead of the earlier simple crosses, more and more complicated crosses are carried out, in which phytotron techniques are used. Thus, hybridisation programmes take about half the time required under field conditions. Nota bene! In the phytotron frost hardiness is also tested all year round. The selection system is based on pedigree breeding and, in order to increase the efficiency, the treatment of the breeding stock is mechanised as far as the technical equipment available allows.

In each year of the seventies a Martonvásár winter wheat variety has been given state qualification (Mv 1, Mv 2, Mv 3, Mv 4, Mv 5, Mv 6). The economic value of these varieties is steadily improving. In national variety trials over the last seven years, the yields given by Martonvásár wheats in 1970, 1971 and 1972 were approximately equal to that of the standard, and foreign or other non-Martonvásár varieties were dominant in both ripening groups. During the last four years of this seven-year period, however, in 1973, 1974, 1975 and 1976, the Martonvásár varieties (Mv 4, Mv 5, Mv 6) were generally dominant in both ripening groups. And the prospects are even more promising: in the near future we are hoping that Martonvásár varieties will restore the reputation of Hungarian wheat, at least in the Carpathian Basin, to what it was in the days of the Bánkúti wheats.

c) Since 1964 hybrid wheat research based on male steriles and restorers has been carried out at Martonvásár parallel to the classical wheat breeding. This developed as an offshoot of the wheat flowering biology research initiated in the late fifties (Rajki, E. 1962), the results of which were useful in both hybrid wheat breeding and seed production. The fundamental problem, that of efficient fertility restoration, was solved a few years ago. The solution of other problems which still prevent the practical introduction of the method (heterosis in straw length, suitable stand heterosis) will be time consuming, but should prove possible (Rajki 1976).

The relationship between hybrid wheat research and classical wheat breeding at Martonvásár may be characterised as a positive interaction. The male sterile analogues and the restorer lines are produced from the best cultivars. But hybrid wheat research also has a positive effect on classical wheat breeding. Thus, of the six Martonvásár winter wheat varieties which have so far received state qualification, five originate basically from Bezostaya 1 × Fertődi 293 and Bezostaya 1 × Mironovskaya 808 hybrid populations. Attention was drawn to these populations as possible initial stock for breeding during investigations on the combining ability of hybrid wheat. The experimental results of several years showed that the approximately 40% grain yield heterosis observed in the F_1 of these combinations compared to the standard, Bezostaya 1, was still significant in the F_2 (Rajki, E.—Rajki 1968).

The main role in both classical and hybrid wheat breeding is now played by the up and coming generation of researchers, most of whom, including the leader of the wheat breeding team, have been working under me for fifteen years or so.

d) The autumnisation research carried out over the last two decades, as a result of which a number of spring wheats, including several of Borlaug's varieties, have been autumnised in open field experiments (Rajki 1967, 1975a, 1975b, Rajki, E.—Rajki 1969), has been concentrated for the last few years on the phytotron, which we ourselves literally conceived and constructed, and which is the one place where experimental conditions can be reproduced. Nature never repeats herself exactly, yet the reproducibility of the experimental conditions is a criterion without which biology can never become an exact science such as physics or chemistry (Rajki 1973).

Only a few factors of the critical autumn effect can be simulated in the phytotron; nevertheless, the results achieved during the past four years of phytotron experimentation give us grounds for hoping that the gradually decreasing temperature and light intensity, the shortening daylength and the relative increase in long wavelength radiation in the spectrum, i.e. those autumn conditions which are reproducible in the phytotron and which are diametrically opposed to the corresponding tendencies dominant in the spring, will prove to be among the most important factors in the autumnisation process. The proper programming of the water and nutrient supplies to the plant material used in the autumnisation experiments also causes no little concern.

Winter habit, as an adequate genetic variation developing due to the effect of a changed environment, i.e. as the result of a modification in the metabolism corresponding to the environmental effect, and lacking in the initial spring wheat, is a case of the inheritance of acquired characters, i.e. of adequate variability (RAJKI 1966, RAJKI *et al.* 1972). Since an adequate change corresponding to the direction and dimensions of the factor producing the change is brought about in the effect, the setting up of this scientific thesis is admissable, in accordance with the law of causality, even if some steps in the process are not clear, provided the end result is known.

The essential feature of CRICK's (1958) central dogma, the impossibility of information transfer in the opposite direction, is per se undemonstrable, but according to the rules of logic its contrary is to be proved. In the same way the proof of the existence of the gene is a logical absurdity, because according to the classical and/or molecular gene concept this does not only signify the genetic material (the "DNA molecule") but also expresses the specific relationship between heredity and metabolism, the body and its environment, i.e. the impossibility of any adequate transcription of the information due to changes in the environment or the metabolism. Here too only the contrary can be proved. It is for this reason that the irrefutable proof of any adequate genetic variation, or, to quote CRICK (1970), the realisation of "any of the unknown transfers", would "shake the whole intellectual basis of molecular biology". Similarly, it is only "judicious" to discourse on the chemical preparation of a gene, i.e. a "DNA molecule" independent of changes in the environment or the metabolism, as long as no adequate variation has been irrefutably proved.

With the exact reproduction possible in the phytotron, autumnisation, the induction of an adequate genetic variation, could become an attractive field of research. After all, what does the induction of adequate variability in the phytotron under reproducible conditions signify? It signifies that the conditions required for the genesis and development of certain agronomic characters can be determined, and this knowledge can be used in planning and realising the programmed production of these agronomic characters.

What am I thinking of here? Let us suppose that we have already learnt how to produce agronomic characters in a programmed manner on our experimental plant, wheat. In other words, as the result of adequate variability we would then be in possession of an ideal wheat population, the genetic formation of which would not be limited by environmental factors but at most by specificities characteristic of the species itself, and which would not be restricted even theoretically in the manifestation of its potential. Thus, not only would the way be open for the programmed production of wheat with undreamed-of productivity, but also for that of winter wheat with frost and winter hardiness capable of withstanding the rigours of the hardest winter. In a non-limiting environment, where the potential can be freely manifested, the variance due to the environment will be at a minimum and the efficiency of selection at a maximum. Even the best farms will have to be adapted to make way for the elite plant progeny, the super wheat, selected from the ideal wheat population, but by the turn of the millenium, when the ideal or super wheats can be expected to appear, this adaptation will no doubt have taken place.

Naturally, much of this is still hypothetical, though "all" that is needed to prove it is for the programmed production, the genetic optimation, of at least one agronomic character to succeed. However, the genetic optimation of agronomic characters is hardly conceivable without the optimation of the plant raising procedures, so the elaboration of both is regarded as the main task confronting the staff of our phytotron. We hope that our working hypothesis will be proved during the next 10—15 years and that genetic optimation, i.e. programmed adequate variability, will become a reality. Surely this must be the non plus ultra of any geneticist's dreams. This is the path on which László Baross took one of the first steps when he autumnised Marquis in his wheat nursery, and which leads towards the genetics of the third millenium.

It says much for the Hungarian Academy of Sciences that they do their best to realise the ideal of freedom in scientific research. "The history of science bears witness that it is precisely the most revolutionary theories which give science the greatest impetus, theories which are based on new interpretations of known facts, or even on the revival of theories regarded as out-of-date by filling them with new import", wrote ERDEY-GRÚZ (1968), the recently deceased president of the Hungarian Academy of Sciences. He concluded: "...we must be very careful not to suffocate new ideas which deviate from traditional theories". For this reason, if for no other, those who covertly or openly vilify the Hungarian Academy of Sciences because of the autumnisation research carried out at Martonvásár, or who expect the Hungarian Academy of Sciences to take administrative steps against the autumnisation research at Martonvásár (EDWARDS 1968, DUBININ 1974) have not achieved their aim, nor are they likely to do so in the future. There is and can be no creative science without the freedom to express and defend minority opinions. How fortunate that the fires no longer burn under the stakes at Florence and that the "Holy Office" in Rome has ceased to function! What is more, it seems that it is only a question of time before the high ideal formulated long ago in the phrase "Cogitationis poenam nemo patitur" becomes generally valid.

4. Food — the burning question of our age

It would be difficult to dispute the fact that in our changing world, quite independent of the socio-economic system, human progress depends more and more on the achievement of an abundance of food and on research leading to this end. Food is the burning question of our age, and not only for the third world. For the present, that third of the world in which we live is still obliged to pay thousands of millions of dollars a year for corn.

It is a well-known fact that less than 10% of humanity lives in countries which can not only be regarded as self-supporting with respect to food, but which also have a surplus at their disposal. And yet, in order to maintain any human activity whatsoever the prime necessity is to keep ourselves alive, and first and foremost this requires food. As long as there is a lack of food anywhere in the world, food will be the hardest currency of all for those fighting the shortage and the strongest weapon in the hands of those who have a surplus. This situation demands that the development of agriculture and of agrobiological research in Hungary, as elsewhere, should be given the highest priority.

Our own poverty in energy and industrial raw materials only serves to underline the need for this priority, since the building blocks of food are essentially atmospheric carbon dioxide and nitrogen, minerals from the soil, and water from precipitation and the ground, while the energy is provided by sunshine. All of these are available plentifully, cost-free and in excellent quality in Hungary.

The Agricultural Research Institute of the Hungarian Academy of Sciences, of which, by a special dispensation of providence, I was one of the founders, and of which, after the first six years of its existence, I became the director some 22 years ago, is operated in this spirit.

In the interests of increased efficiency the intellectual and financial resources of the Academy's institute and farm at Martonvásár have gradually been concentrated, ever since my first years at the institute, on basic and applied research on wheat and maize, two of the most important cultivated plants at both a domestic and a world level, with the emphasis on specialisation and on reducing the time required for the realisation of research results of practical importance.

The road on which we are travelling is contradictory and by no means free of problems, but the way in which the contradictions can be resolved and the problems overcome is by no means unknown to us. And it seems we were born to devote ourselves to genetics and agrobiology and to the development and future of the Academy's institution at Martonvásár.

But not even the most noble scientific endeavour can replace the human touch, at which we are continually striving. Our many Hungarian and foreign friends represent a powerful force which is of great assistance in overcoming the difficulties and in realising our ideas.

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CHRONICA

JÁNOS MÓCSY
1895—1976

János Mócsy, Member of the Hungarian Academy of Sciences, Kossuth-Prize and State-Prize laureate, outstanding personality of Hungarian and international veterinary science, the great teacher of generations of veterinarians, has left us forever. A life entirely devoted to work, full of struggles but crowned with success, has come to an end. We have been bereaved of a prominent representative of the heroic era of veterinary science in this country.

János Mócsy's life-work was the culmination in a process of development which started at the beginning of this century with Ákos Azary. The discipline of "clinical veterinary medicine", then created by Azary, evolved through the contributions of his successors, József Marek and János Mócsy, into a new school of thought, the principles of which penetrated veterinary thinking all over the world.

János Mócsy was born in Kalocsa, Hungary, on the 30th November 1895. He was admitted to the Veterinary High School in 1913, and soon distinguished himself by his talents and diligence. Although his veterinary training was interrupted by World War I, he not only made up for lost time, but graduated with distinction in 1918.

He started his career as Assistant Professor in the Institute of Bacteriology, then headed by A. Aujeszky, then in 1922 he joined the Internal Disease Department as co-worker to J. Marek. In 1926 he was awarded a Rockefeller fellowship and spent 10 months at the Veterinary and Agricultural High School in Copenhagen, Denmark, and at the Veterinary Institute in Hannover, Germany. His great devotion to work promoted his professional progress: he was appointed Senior Lecturer in 1927 and Honorary Lecturer in 1929. When J. Marek retired in 1935, he succeeded him as head of the Department and Clinic of Internal Diseases. He was appointed to an assistant professorship in 1936 and to a full professorship in 1940, and held the post of director of the above Department and Clinic until his retirement in 1961. Apart from this, during the academic year 1949—1950 he served as Dean of the Veterinary Faculty of the University of Agricultural Sciences, and from 1954 to 1956 as Director of the newly independent High School of Veterinary Science.

His retirement in 1961 surprised his colleagues and friends. "The proper time for retirement arrives when you yourself notice a decline in your strength and not when everybody but you notices it." His words reflect a deep sense of responsibility, sagacity and strength of character. A new sphere of activity awaited him on his retirement from higher education: for six years he acted as the Head of the Department of Agricultural Sciences of the Hungarian Academy of Sciences.

János Mócsy, the great veterinary scientist and teacher also distinguished himself by outstanding personal qualities. He was made a member of the Hungarian Academy of Sciences 35 years ago, and was head of the Academy's Agricultural Science Department for a period of six years. Among his many merits as a scientist the greatest was perhaps to develop his new outlook on veterinary medicine into an independent school of thought, often referred to as the "Marek—Mócsy" school. Á. Azary's pioneer efforts towards the creation of the discipline of "clinical veterinary medicine" at the turn of the century were furthered by J. Marek's contributions to veterinary clinical diagnostics, while János Mócsy crowned these achievements with a scientifically founded approach to disease problems, advocating the maximum utilization of the interactions between practice and research.

It is beyond the scope of this obituary to list all his contributions to the progress of veterinary science, since he did important work in practically all fields. Thus only Mócsy's principal achievements are referred to here in brief. Veterinary diagnostics profited greatly from the detection of the place of origin of the vesicular respiratory sound by János Mócsy. He demonstrated that post-inoculation paralysis occurring after vaccination against rabies was unrelated to the causal agent, being due essentially to a focal lymphocytic encephalomyelitis; there is no infective agent in the nervous system. He showed that infectious anaemia is transferable from one animal to another not only with whole blood and filtered serum, but also with the serum albumin and globulin fractions. He concluded that the virus was not a living organism, but only a "pathological metabolic product", synthesized as one member in a reaction series triggered by the entrance of an infectious dose of virus into the organism. He recognized that in cattle a repetition of the subcutaneous tuberculin test gives rise to hypersensitivity (doubtful or positive eye test), which accounts for diagnostic errors. For the radical treatment of ovine scabies he recommended a dipping solution containing the gamma isomer of HCH, which has been noted for its long-lasting residual effect. Treatment with a contact poison was an entirely new therapeutic approach to this disease, and it was utilized with success on a national scale in the eradication of ovine scabies, which had previously been responsible for great economic losses. Mócsy was the first to show that various cutaneous diseases (scabies, demodicosis, lice) can be successfully cured by the oral administration of contact poisons. He recommended sulphamethylthiazol for the parenteral treatment of fowl cholera. He made many observations of cauistic importance in all fields of internal medicine and worked on the improvement of therapeutic techniques.

János Mócsy was one of the first veterinary scientists to recognize the role of environmental factors in the etiology of the so-called multifactorial diseases noted for mass incidence in intensively managed large herds and flocks. He urged the setting up of investigations into the possibility of controlling diseases which affect young animals and initiated such research in his department in 1952. He also published many papers on this topic.

As well as nearly 200 research papers, he also wrote several textbooks and manuals, which had the special merit that in each topic discussed he was able to rely on his own profound experience, with due regard to the opinions of others. His clear and concise presentations and admirable language also contributed to the recognition which his books won him both at home and abroad. His books, some of which were written with co-authors, are listed here in order of publication. János Mócsy compiled the revised 3rd an 4th editions of J. Marek's "Klinikai diagnosztika" (Clinical Diagnostics), and wrote the textbook "Állatorvosi klinikai diagnosztika" (Veterinary Clinical Diagnostics), also published in Polish in two editions. The books entitled "Belgyógyászat állatorvosok és állatorvostanhallgatók számára" (General Medicine for Veterinary Surgeons and Students) and "Állatorvosi Belgyógyászat" (Veterinary Medicine), both in two volumes, were written in co-authorship with R. Manninger, and the latter was also published in Slovakian, French and Vietnamese. "Lehrbuch der Klinischen Diagnostik der inneren Krankheiten der Haustiere" (Textbook of Clinical Diagnostics for Internal Diseases in Domestic Animals), written with J. Marek as co-author (4th, 5th and 6th edition), was also published in Polish and Spanish. "Spezielle Pathologie und Therapie der Haustiere" (Special Pathology and Therapy of Domestic Animals), in two volumes, was written in co-authorship with F. Hutyra, J. Marek and R. Manninger (9th, 10th and 11th editions), and was published in Polish, Russian, Chinese and Spanish; "Állathigiénia" (Animal Hygiene), with I. Szép as co-author, was published in Hungarian and Polish.

Apart from his versatility and exceptional accomplishments, his engagement in a wide orbit of scientific activities accounted for János Mócsy's excellence as a teacher. In his own words: "Teaching at university level presupposes active participation in the improvement and development of the chosen discipline."

His singular sense for didactics and teaching, and his informal approach to his pupils won him whole-hearted recognition and respect. The demonstrations he held were model examples of training in the medical outlook. He was an inexhaustible source of information derived from experience and not to be found in any book. His observant mind, unusual reasoning powers and intuition, and his keen practical sense never failed to impress his students. His conduct was an attractive example of professional dedication, sense of order and noble simplicity. Thus, apart from bestowing on his pupils professional knowledge, he also contributed to the education of their personality and took every opportunity to impress on their minds the superiority of community interests and welfare to those of the individual.

János Mócsy will also be remembered for his activities in educational organization and development, first as Dean of the Veterinary Faculty and later as Director of the High School of Veterinary Science. He held these posts during a critical period, but still managed to bring about improvement. His attitude was thoroughly humanitarian and he was always ready to help when asked to do so. His puritanic mind disapproved of formalities, and he preferred simple frank communication at all levels of personal contact, declining with his characteristic acrid humour all manifestations of over-politeness and flattery. His versatility deeply impressed everyone who had the chance of an insight into his rich personality.

Professional excellence, which made him reputed all over the world, was entwined in János Mócsy with a genuine liking for the arts and literature. His sophisticated taste in literature made itself felt in his own contributions as a professional writer. His style of writing was noted for an extraordinary clarity and conciseness, unusual in scientific literature. His ability to get to the heart of the matter, and his dislike of circumstantial phrases and euphuisms gave rise to a certain anxiety even in the best professional writers when approaching him as reader.

He admired the arts, and indulged in ancient history and archaeology as his special hobby. (He left behind a valuable collection of Roman coins and objects.) He himself made artistic drawings and paintings, and was an excellent photographer. He prepared most of the illustrations for his books himself.

The contributions of János Mócsy as teacher and scientist have been duly appreciated by the Hungarian Government. Few people have received as many awards of honour as he did: Order of the Hungarian People's Republic (Grade V) in 1951, the Kossuth Prize in 1952, the Red Banner Order of Labour in 1961, the Gold Medal of Labour in 1965. In 1970 he was awarded the State Prize (Grade I) for his life-work and for his outstanding achievements in veterinary medicine, in the reinforcement of the international reputation of Hungarian veterinary science and in the training of veterinarians. The Government marked his 80th birthday in 1975 by awarding him the Order of the Banner of the Hungarian People's Republic (Grade II).

Recognition was also given by the world of science both at home and abroad. János Mócsy was elected as a corresponding member of the Hungarian Academy of Sciences in 1941 and as a full member in 1946. For six years he held the post of Secretary of the Department for Agricultural Sciences at the Academy, and for several years he was an elected member of the Academy's Board. He was awarded an honorary doctorate by the University of Veterinary Science, Budapest, in 1962, and by the Veterinary Faculty of the Humboldt University, Berlin, in 1965. The Board of the Hungarian Association for Agricultural Sciences awarded him the Ferenc Hutyra Memorial Medal in 1961, for social and scientific organisational activities on behalf of the Association. He was the first holder of the József Marek Memorial Medal, set up at the University of Veterinary Science, Budapest, in 1975. This honour was bestowed on him in recognition of his outstanding achievements in the teaching, practical application and development of the veterinary sciences.

F. Kovács

RECENSIONES

KAUSO ASAMA: *The Origin of the Angiosperms* (Evolutionary Biology in Plants IV., Sanseido Co. Ltd., Tokyo, 1975, 400, Fig. 164. In Japanese).

The name of this famous author is well-known among paleobotanists, especially in connection with his theory of retardation evolution. His present book is in fact a synthesis in which he reviews with comparative criticism and with great competence all the important theories in the world about evolution, but his main interest is the origin of the Angiosperms. From our point of view, it is a pity that in the whole book there is not a single sentence or word in a foreign language, such as English; only the names of authors, plants and taxonomical categories are printed in Roman characters. Nevertheless, the 164 pictures and drawings and the large number of tables give us a glimpse of the inner contents of the book. The figures illustrating the most famous evolutionary taxonomical charts are especially valuable; having compared them, the different evolutionary systems can be surveyed better.

From among the most important contemporary theories, he presents those of the Dutch H. Lam and A. Meeuse, the German W. Zimmermann, the Soviet A. Takhtajan, the American D. Axelrod, and the Hungarian P. Greguss. He deals separately with only two of them, that of the American Axelrod and of the Hungarian Greguss, who derive the polyphyletic genesis of the land-plants independently from marine origin. He thinks highly of the theories of Axelrod and Greguss, about which he writes the following (these paragraphs are a literal translation from Japanese to English):

"Axelrod thought that the plants generally referred to as ferns do not form one single natural phylum, but they could be divided into several branches, while the evolution of the Gymnosperms could be derived as seen in Fig. 7. According to him, the plants with small leaves and with verticillate leaves have remained in the sporophytic phase, but they are not at all related to the ferns. Within the Angiosperms, both the Monocotyledons and the Dicotyledons developed separately from the ferns, that is, he derived the Angiosperms differently than other scientists."

"There is also a scientist whose particular ideas outline a triple origin of the land-plants. This scientist is the Hungarian Greguss (1964), who first published his ideas on the subject over 50 years ago in 1918. He first studied the anatomy of the ligneous plants, then published several books on the Gymnosperms and the Angiosperms. He has also written about fossilised plants and has recently studied the Sago-palms."

"The basic idea behind his theory is shown in Table 8; different regularities have survived from the cellfathom state to the most complicated plants, and as basic modes of branching, none of them could have developed from another. In his opinion there is no evidence that in forked branching a sideshoot overgrew, thus giving rise to branching from a common base. Right from the beginning the three systems developed side by side until the present-day angiospermal state was reached."

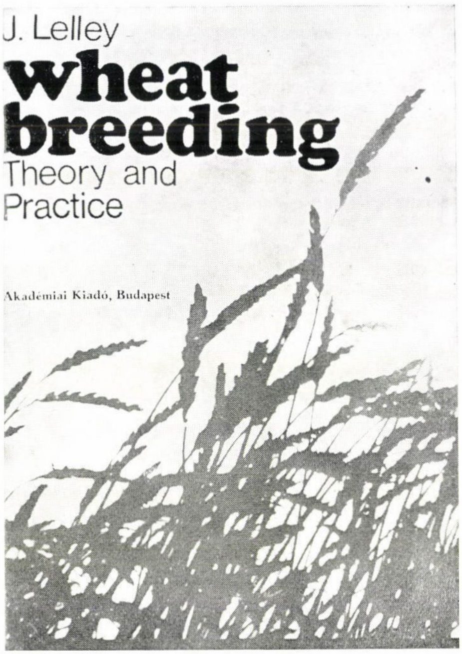
In a survey covering more than three pages, he describes the isospore, homospore, heterospore, isosperm, homosperm and eusperm states, which fit completely into Greguss's chain of thought.

"According to this theory, plants with the same kind of reproductive organs will belong to the same phylum. The plants reached different evolutionary stages in different geohistorical eras. On the basis of the above, the Axelrod multi-philic theory, and the Greguss triple-theory of cormophyte plants were developed."

In connection with the survey, the author refers several times to Greguss's table.

This well-presented book will be a great help to those studying the evolution of plants.

GY. CSONGOR



J. LELLEY: *Wheat Breeding. Theory and Practice.* Akadémiai Kiadó, Budapest, 1976, 286.

The Author treats the subject of wheat breeding mainly on the basis of recent results in cytogenetics, and more particularly of aneuploidy genetics. Of the results of this nature discussed in the book the most recent are generally those presented at the Fourth International Wheat Genetics Symposium held in August 1973.

This cytogenetic orientation accords with the main contemporary trend in scientific (though not practical) wheat breeding. In this case, however, it is the source of certain, not entirely correct statements and, above all, of the over-evaluation of the practical results of wheat breeding based on cytogenetics. The Author himself is obviously aware of this danger, as may be concluded from the following statement: "The results obtained by the research of substitution and addition are of moderate practical breeding use for the time . . .", but he considers that the reason for this is that "the first complete aneuploid series was produced with Chinese

Spring, a primitive variety" (p. 59). Research of a similar nature, which has been underway for years now on numerous modern varieties, is qualified to decide whether this is really the only reason. A similar judgement can be made of the statement that "Artificially induced gene mutation has become an efficient method in practice of breeding" (p. 187), which again has not yet been proved by wheat breeding in practice.

Nevertheless, the book is generally characterised by exemplary objectivity. For instance, the Author clearly demonstrates that the hypotheses referring to the origin of the A, B and D genomes and of the tetra- and hexaploid groups of wheat species have become questionable. A still better example of the Author's scientific objectivity is his standpoint on the utilisation of adequate variation in breeding (pp. 85, 193—194). Although the Author is well aware that adequate variations are inexplicable according to the prevailing genetic concept which he espouses, his respect for the facts takes precedence over everything, in contrast to the attitude exhibited by certain geneticists. It would not be out of place to mention here that of all winter wheats Mironovskaya 808 (p. 85), which was selected from an autumnised population, is now sown on perhaps the largest area in the world. This explains why the outstanding wheat breeder Maksimchuk considers autumnisation to be a breeding method comparable to hybridisation. The book very rightly includes two mentions of this, once under "Winterhardiness" and again under "Induction of adequate variations". It is a pity, though, that unlike the first reference (p. 85), the second reference is erroneous: instead of Maksimchuk and autumnisation the text reads Maksimenko and vernalisation (p. 194).

The book, which consists of 286 pages including 26 tables and 60 figures, is published by the Publishing House of the Hungarian Academy of Sciences and is divided into 14 chapters and References. It begins with a survey of the literature previously published on the subject and continues in Chapter 2 with the origin of wheat. Chapter 3 deals with the role of wheat breeding in world economy, while taxonomy is the subject of Chapter 4. The Author introduces the chromosomes of wheat in Chapter 5 and the control mechanism of homologous pairing in Chapter 6. Gene symbols and gene mapping are the subject of Chapter 7, while the substitution, addition and translocation of chromosomes are discussed in Chapter 8. In Chapter 9, under the title of major quantitative characteristics and the genetic influence, the reader finds sections on yield potential, winter hardiness, drought tolerance, lodging resistance and dwarfness, and time of maturity. In Chapter 10 the Author discusses pathological resistance, with sections on stem rust, leaf rust, yellow rust, powdery mildew and other pathogens, this latter touching on common bunt, dwarf bunt, flag smut, Fusarium, wheat streak mosaic and Hessian fly. Quality improvement is the subject of Chapter 11, which deals with milling quality, baking quality, quality of soft wheats, paste used in vermicelli production (presumably pasta is meant), biological values (digestibility) of wheat, total protein content and amino acid composition. These are followed in Chapter 12 by breeding methods, namely, intervarietal hybridisation, interspecific hybridisation, intergeneric hybridisation, hybrid wheat, haploid method, artificially induced gene mutation, spontaneous mutation and induction of adequate variations. Chapter 13 is divided into two subchapters dealing with the bulk method and individual selection. Finally, Chapter 14 discusses the mechanisation of wheat breeding.

Despite the unusually extensive References, which covers 63 pages and includes some 1500 citations, the book contains no superfluous details. It is a pity that there are no indexes of Latin plant and animal names, or of names of varieties, and no alphabetical Author and Subject indexes, which would have helped the reader to orientate.

The English translation is comprehensible, though certain technical expressions are not sufficiently accurate. For instance, apart from the example mentioned above (vernalisation instead of autumnisation) seed-grain is used throughout in place of seed.

These few errors and deficiencies, however, do not significantly retract from the value of the book, which is excellent of its kind. The Author is a very competent specialist on wheat breeding, his style is clear and concise and his work reflects the present state of science. Apart from wheat breeders and geneticists, the book is worthy of the attention of seed specialists, and will also be useful to all agricultural and plant biology specialists and university students wishing to obtain a deeper knowledge of this subject.

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РЕЗЮМЕ

МАТЕМАТИЧЕСКАЯ МОДЕЛЬ ИЗМЕНЕНИЯ ЛЕГКОРАСТВОРИМОГО В ПОЧВЕ ФОСФОРА В ЗАВИСИМОСТИ ОТ ФАКТОРА ВРЕМЕНИ

Л. БЁРЖЁНИ, Г. ФЮЛЕКИ

В работе изучается изменение содержания легкорастворимого фосфора после удобрения почв с разным механическим составам и при 9-ти pH. Временное изменение данного процесса регистрируется обычным первостепенным дифференциальным уравнением $y' = -by^c$ при дозах 280, 28 и 2,8 мг P_2P_5 на 100 г почвы. Изложенные результаты дают возможность сделать некоторые соображения в направлении исследования параметров, в разъяснении агрохимических концепций и для дальнейшего развития проблемы.

НОВЫЙ МЕТОД ДЛЯ ОПРЕДЕЛЕНИЯ САМООПЛОДОТВОРЕНИЯ У СОРТОВ СЛИВЫ И РЕНКЛОДА

Д. ШУРАНИ

Автором было исследовано 17 самооплодотворяющихся, 7 частично самооплодо творяющихся, 7 практически самостерильных и 23 самостерильных сортов сливы. По размеру пестика, по количеству функциональных пыльников, по частному SN/PL и по средней величине длины части побега между двумя листьями, была найдена разница между различными группами по оплодотворению. Величина пестика оказалась наибольшей у частично самооплодотворяющихся сортов, а у самооплодотворяющихся величина пестика была меньшей. Самостерильные и практически самостерильные сорта характеризуются короткими пестиками. По количеству пыльников, наоборот, наблюдалось обратное отношение, наибольшее количество пыльников было насчитано у самостерильных сортов. Исследование сортов по группам показало, что частное SN/PL является выгодным для характеристики самооплодотворения: частное у частично самооплодотворяющихся сортов меньше (1,85 pc./mm), а у практически самостерильных и у самостерильных сортов частное варьирует от 2,24 до 2,35 pc./mm, то есть относительное количество пыльников выше оптимального. Величина частного является выражением половой корреляции. На основании исследованных 1620 цветков была найдена достоверная отрицательная корреляция между величиной пестика и количеством функциональных тычинок. Проведённое в середине лета исследование показало, что между частным и средней величиной длины побега между двумя листами при 2-х процентной достоверности соотношение ($r = +0{,}259$). В конечном итоге частное и величина длины побега между двумя листами являются подходящими показателями для характеристики самофертильности у сливы. Метод простой и легко осуществимый, таким образом быстро можно оценить большое количество сортов, кандидатов в сорта (отселектированных и доместифицированных), гибридов и, по мере возможности, и популяций подвоя.

СЕЛЕКЦИЯ ЯРОВОГО ЯЧМЕНЯ НА УСТОЙЧИВОСТЬ К ПОЛЕГАНИЮ

Э. ПОЛЛХАМЕР

В течение многих лет мартонвашарские сорта ярового ячменя изучались по устойчивости к полеганию на основе полевых наблюдений, с помощью измерений высоты растений, определением отношения между урожаем зерна и полеганием, измерением поверхности листьев одного стебля и определением комплексной величины устойчивости к поле-

ганию (KÁÉ). Были выделены партнеры для скрещивания, подходящие для улучшения устойчивости к полеганию или для улучшения отдельных составных элементов его. По устойчивости к полеганию мартонвашарские сорта ярового ячменя распологаются в следующем нисходящем порядке: Мв 46, Мв 43, Мв 45, Мв 48, МК 42, МК 47 и Мв 41.

ИДЕНТИФИКАЦИЯ ТРАНСЛОКАЦИЙ В СОРТАХ ПШЕНИЦЫ МИРОНОВСКАЯ 808 и РАННЯЯ 12

Й. ШУТКА

Анализировали материнские клетки пыльцы в скрещиваниях каждой из 21 моносомной линии Chinese Spring с Мироновской 808 и Ранней 12. Найдено, что сорт Мироновская 808 отличается от Chinese Spring по двум реципрокным транслокациям, включающих с одной стороны хромосомы 3A и 3B, с другой — 1B и 2D. Предполагется, что Ранняя 12, по сравнению с Chinese Spring, имеет транслокацию, включающую хромосомы 1B и 2D. Частота материнских клеток пыльцы с тривалентами и квадривалентами, в скрещиваниях изученных сортов пшеницы, была относительно низкая.

JÁNOS DI GLÉRIA
(1899—1976)

It was a great loss for Hungarian and international soil science and plant nutrition when Prof. János di Gléria, doctor of agricultural sciences, died on 21st June 1976. With his death an eventful life came to an end.

He was a prominent respresentative of the 'Sigmond-school, a pioneer of soil science and soil colloids, and a highly qualified expert on the science of plant nutrition.

Having graduated at the Budapest Technical University in 1924, he worked as a chemical engineer under the leadership of Elek 'Sigmond, and acquired a doctor's degree in technical sciences in 1927. Then he changed his post as professor's assistant for research activity carried out at the National Institute of Chemistry, where he later became head of department, and directed the work of the soil science, plant nutrition, plant protection and water testing departments. The period in which he carried out his scientific work coincided with the upswing of soil science in Hungary, which he not only directed but in which he also took an active part.

As the holder of a scholarship he became acquainted in 1930—31 with the work of the Wiegner-school, and he himself carried out investigations on colloid chemistry at the technical university in Zurich. This period had an influence on the whole course of his life. It was there that he made the acquaintance of many outstanding representatives of soil sciences, such as professors V. A. Kovda, A. Musierowicz, N. Cernescu and F. Scheffer, with whom he established a close friendship.

From 1942 onwards he organized and directed the Agricultural Experimental Station at Budakeszi, where he remained until the end of World War II.

Later, in 1946, he was appointed professor at the Debrecen University of Agricultural Sciences where he delivered lectures in agricultural chemistry. Besides being head of department, he contributed greatly to the general development of chemical education. He was active in this field at the Debrecen University of Arts and Sciences, where he delivered lectures in physical chemistry and colloid chemistry.

In 1950 he returned to Budapest as a researcher at the Research Institute of Agrochemistry, of which he was director from 1954 to 1957. This period of his life was particularly fruitful. Besides making his mark as a scholar through his personal research work, as director of the institute he promoted the development of the fields of science he represented by organizing cooperation between experts within and without the institute.

It was during this period that he wrote his works on soil acidity. It is owing to him that our views on soil acidity have changed, and the process is no longer explained mechanically by the fixation of protons on the colloid surfaces, but apart from this a change in the adsorption surface itself is also reckoned with.

His comprehensive work "Talajfizika, talajkolloidika" (Soil physics, colloid chemistry of soils) (1957), written with Andor Klimes Szmik and Miklós Dvoracsek as co-authors, was published during the same period. Its topicality and high professional level was proved by the fact that the German publication (1962) was also sold out in a short time.

Equal importance is attached to the books he compiled on the subjects of applied soil science and plant nutrition: "Mezőgazdasági kémia" (Agricultural chemistry) (1950), "Talajvizsgálati módszerkönyv" (Methodology of soil testing) (1953, 1962) and "Mezőgazdák talajismereti és trágyázási útmutatója" (Soil science and plant nutrition guide for farmers) (1958, 1964).

All this shows that he was one of the leading scientists of his day, whose views on the unity of soil science and plant nutrition became, through the efforts of him and his co-workers, the theoretical basis of everyday practice in agricultural production.

The initiative which resulted in the organization of a work group engaged in the application and improvement of isotope techniques at the institute he directed was also of great importance. The introduction of this up-to-date technology was the starting point for many new results and it was on this that the book "Izotópok alkalmazása a mezőgazdasági kémiában és talajtanban" (Application of isotopes in agricultural chemistry and soil science), compiled by him and published in 1966, was based.

Apart from his scientific research work, he also made an important contribution to scientific management. He was the first president, and later the honorary president of the Hungarian Society of Soil Science, and was also president of the Soil Science Committee of the Hungarian Academy of Sciences for a long period. He was an honorary member of the German Society of Soil Science and a member of the International Society for Soil Science.

He was member of the editorial board of "Acta Agronomica" and "Agrokémia és Talajtan".

His international fame was due partly to his work in the International Society for Soil Science and to lectures delivered at congresses and conferences, and partly to several years of advisory work in Cuba. In Cuba he organized the up-to-date instrumental research work at the Havana Institute for Soil Science, and trained experts to continue his work when he left.

In recognition of his work he was awarded the gold medal of the Order of Labor, the title of Prominent Worker in Agriculture, and the Tessedik Medal.

He was an exemplary human being. His life was a model of now to render full service both to Hungarian and international science, and also to the family and the close community in which he lived and worked.

All his deeds were characterized by the logical order that imbued his whole life and directed his professional work. His modesty, unselfishness and helpfulness made him available to all who turned to him. His research work was characterized by its accurate and methodical nature, and the results were reported simply and intelligibly.

He paid great attention to the professional development of his contemporaries and young co-workers. In his lectures as well as in personal conversations he called attention to current problems. He provided guidance by his advice, and even more so by means of joint projects. He was always ready to share his knowledge and render it useful in collective work, as proved by the publications he wrote with co-authors, and by the books published as a result of the work of a team of authors under his editorial guidance.

He exchanged opinions not only with the representatives of his special field, but was able to offer views worthy of consideration in other associated sciences, and to find possibilities for collective work. It can thus be said that in him we have lost a prominent representative and successful follower not only of soil science and agrochemistry, but also of the whole sphere of agricultural sciences.

P. Stefanovits

Acta Agronomica Academiae Scientiarum Hungaricae, Tomus 27 (3—4), pp. 233—246 (1978)

MATHEMATICAL MODEL FOR TEMPORAL CHANGES IN THE READILY SOLUBLE PHOSPHORUS CONTENT OF SOILS

By

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This paper follows the changes in the readily soluble phosphorus content of 9 soils of different pH and mechanical composition after phosphorus fertilization. The temporal changes of the process on applying 280, 28 and 2.8 mg P_2O_5/100 g soil are described by the ordinary differential equation $y' = -by^c$. The paper also considers parameter examinations, agrochemical interpretations and the extension of the problem.

Introduction

The first reaction which solid phosphorus fertilizer undergoes when introduced into the soil in the course of phosphorus application is dissolution. Inasmuch as it is a water soluble fertilizer this step takes place quite quickly, in a matter of a few hours. In the second step this phosphate solution enters the solid phase of the soil in a labile form, after a fast reaction. Then from this labile state the phosphate passes over — in the third step — into a non-labile state. The latter reaction, however, takes place more slowly (LARSEN 1971).

The labile phosphorus content, increased by the application of phosphorus fertilizer, begins to decrease at once in the above-mentioned third step. Experience shows that this takes place quickly at first, and later at a slower rate. The time spent in a labile form by the phosphate added to the soil can best be characterized by the half-life. By half-life we mean the time during which half the amount of phosphate added to the soil becomes non-labile. LARSEN *et al.* (1965) found that in non-acidic mineral soils the half-life ranged from 1 to 6 years and was in most cases about 2.5 years. According to these authors, the amount of phosphorus in the labile state decreases exponentially with time. Further, they demonstrated that the transformation of labile phosphorus into a non-labile form depended on more than one factor, but they did not find any correlation between the half-life of the labile phosphorus content, on the one hand, and the clay content, the amount of organic matter and the soluble iron and aluminium contents, on the other. According to the authors cited, it is not probable that the substantial differences in the half-life of the labile phosphorus content in different soils is caused solely by the different absorption capacities of the soils. The pH value was the only soil property found to be in correlation with the half-life. The half-life of labile phosphates increased linearly with the hydrogen ion concentration. In most cases the decrease in lability in the 6.0—7.5 pH range of the soils they studied was assumed to be caused by the formation and aging of calcium phosphates.

The change in the labile phosphorus content reflects its varying availability to the plant. Conventional solvents are also used to follow the change in the amount of available phosphorus. Changes in the amount of phosphorus dissolved by these solvents are related with the changes in the amount of phosphorus available to the plant. It is thus desirable to examine the solubility of the phosphorus fertilizer introduced into the soil. SHELTON—COLEMAN (1968) found the decrease in the readily soluble phosphorus content of the examined soil to depend on the rate of fertilizer application. In the case of higher fertilizer doses, the decrease in the first two years proceeded at a faster rate than during the subsequent 6 years. With lower fertilizer doses the initial quick reduction in the readily soluble phosphorus content did not take place; only the slower decrease experienced with higher doses was observed.

After-effect experiments to find out what happens to phosphorus fertilizers applied to the soil and left unused by the plants have been carried out all over the world. The results of one of the best known series of after-effect experiments carried out at Rothamsted, Woburn and Saxmundham (MATTINGLY, 1971) show that phosphorus fertilizer applied in the form of superphosphate only partly retained its effectiveness and availability to plants as time progressed, and depended on the pH of the soil and the test plant employed. In the neutral and carbonate soils examined by the same author, solution in $NaHCO_3$ clearly showed the trend of availability to plants of the phosphorus fertilizer left in the soil.

Many other experimental data may be mentioned to confirm that the effectiveness of phosphorus fertilizers applied to the soil decreases with time as a function of certain soil properties. However, to describe the extent of the decrease only the percentage changes are generally used (MATTINGLY 1971), or the contents themselves with the graphic illustration of the changes (SHELTON—COLEMAN 1968). The initiations and results of modelling, describing in a mathematical form, the temporal change in the labile or readily soluble phosphorus content in the soil after phosphorus applications are less well-known, as is the way in which solubility is influenced by the pH and mechanical composition of the soil and the rate of fertilization. A further question is whether or not all the solvents used show the changes uniformly.

Material and method

The soil samples used for the analyses were taken from uniform plots in the national fertilization trials, left for 4 years without phosphorus application, and from a similar plot in a long-term experiment at Martonvásár. Some characteristic features of the soils are shown in Table 1. The experiment was started in April 1973; 9 different types of soil were included in the experiment, each treated with 0, 2.8, 28 and 280 mg P_2O_5/100 g soil, in the form of powdered superphosphate. The soils were subsequently kept at an optimum moisture level. The ammonium lactate-soluble (AL-P) and $NaHCO_3$-soluble (OLS-P) phosphorus contents of the soils were determined before fertilization, and 1, 27, 84 and 136 weeks after fertilization. (The readily soluble phosphorus contents of the soils left untreated agreed within a reasonable limit of error at the different dates, so changes did not have to be reckoned with here in the course of model construction.) The soil analyses were performed according to the instructions given in "Methods for Soil and Fertilizer Analysis" (Anonymous 1962), and by the techniques of Sarkadi—Krámer—Thamm (1965) and Watanabe—Olsen (1965). The results presented are the mean values of 2 parallel determinations on each sample.

Table 1

Some major characteristics of the examined soils

Number, origin and type of soil	pH	$CaCO_3$ %	Sedimentable part (< 0.02 mm) % (L%)	Initial AL- and $NaHCO_3$-soluble phosphorus content mg P_2O_5/100 g soil	
1. Karcag — meadow chernozem	6.2	—	78	1.5	1.2
2. Keszthely — Raman brown forest soil	6.7	—	50	2.6	1.2
3. Mosonmagyaróvár — Danube alluvium	7.9	23.0	45	13.3	2.9
4. Nagykanizsa — clay infiltrated brown forest soil	5.6	—	50	3.5	2.6
5. Kompolt — chernozem brown forest soil	5.6	—	71	4.0	3.2
6. Kecskemét — mantel sand	7.9	4.1	11	10.6	1.8
7. Martonvásár — forest residue chernozem	7.7	1.1	62	5.2	2.0
8. Putnok — chernozem brown forest soil	6.5	—	70	1.8	2.0
9. Nagyhörcsög — lime coated chernozem	7.8	4.5	53	5.6	1.7

Results

Model construction. Deviations in the regression functions from the measuring points will be minimized on the basis of the long known* principle of least squares. In the present case the method can be applied in the following way. The phosphorus contents y_i of the soils determined at a time x_i are given ($i = 1, \ldots, 4$). The aim is to establish continuous functions adjusted in the best possible way to the discrete points x_i, y_i for the different amounts of phosphorus applied.

* The least square method was used by Gauss in 1794 to estimate the errors of not exactly known numerical values (Wussing 1976).

Let the regression function be an implicit function of the form

$$y = f(x, a, b, c)$$

where y is the dependent and x the independent variable, and a, b, c are parameters. Then with the least square method we can determine those a, b and c parameters for which the sum

$$\sum_{i=1}^{4} w_i \, [y_i - f(x, a, b, c)]^2 \rightarrow \min \tag{1}$$

is a minimum, if the w_i weights are properly chosen (LINNIK 1962). The above is, naturally, also true in general, when x is a vector variable, and the a, b, c parameters are replaced by $a_1, a_2, \ldots, a_k$ and $i = 1, \ldots, n$. In a favourable case it is possible to construct a model whose parameters describe the characteristics given by us: the amount of phosphorus applied, the pH and the sedimentable part (L%).

The regression functions required are the solutions of the ordinary differential equation

$$y' = -by^c \tag{2}$$

where

$$c = \lg d - \lg 2.8 \tag{3}$$

and $d = 280$, 28 and 2.8 mg, that is, the amounts of phosphorus added to the soil. In model (2) the d and the transformed but perfectly identical c parameter correctly describe the change in the phosphorus contents of the soils. The solutions of the differential equation (2) are:
When $c = 2$, ($d = 280$ mg), $y \neq 0$:

$$\int \frac{1}{y^2}\, dy = -b \int dx$$

or

$$-\frac{1}{y} = -bx - a$$

that is

$$y = \frac{1}{a + bx}. \tag{4}$$

When $c = 1$, ($d = 28$ mg), $y \neq 0$:

$$\int \frac{1}{y}\, dy = -b \int dx$$

or

$$\ln y = -bx + k$$

that is

$$y = ae^{-bx} \tag{5}$$

where $a = e^k$.

When $c = 0$, $(d = 2.8$ mg$)$:

$$\int dy = -b \int dx$$

that is

$$y = a - bx. \tag{6}$$

The solutions of (2) form a family of curves in all three cases. The correct integral curve has to be selected from the family of curves, that is, the a parameter must be fixed by substituting function (4), (5) or (6) for the $f(x, a, b, c)$ function in (1), and the realization of condition (1) must be obtained for all values of i at $w_i = 1$.

In the case of function (6) the least square method gives an unbiased estimator (VINCZE 1971). Functions (4) and (5) can be linearized by transformation, that is, written down in the form of $1/y = a + bx$ or $\ln y = \ln a - bx$, for which the same holds as for (6).

The a and b parameters of functions (4), (5) and (6) characterize the L% and pH of the soils. These characteristics do not show such sharp differences in practice as they show in theory, in spite of the frequent errors in measuring. Thus, even in the present case this type of agreement between parameters a and b can only be achieved heuristically.

Heuristic grouping of soils. The soils must first be suitably grouped. The functions of Figs 1 and 2 suggest an obvious way of arrangement. Let us mark the groups with the capital letters A, B, C, etc.; in the brackets, first the numbers of the elements in the group and after the vertical line their pH and L% values are given. Of the pH values concerned 5.6, 5.7 and 6.2 are called low, 6.5 and 6.7 medium and 7.7, 7.8 and 7.9 high pH values. In exactly the same way low, medium and high L% soils are those with the following L% values: 11; 45, 50, 53 and 62; 70, 71 and 78. Further, let us call the a and b parameters within a particular phosphorus dose and series of parameters low, medium and high. Let us examine the comparative values of the a and b parameters within the groups for the three different rates of phosphorus application.

In the case of solvent AL:

$A = \{6;\ 9 \mid 7.9 - 11;\ 7.8 - 53\}$ Soils of high pH and low, medium L% value.

$B = \{2;\ 3;\ 7 \mid 6.7 - 50;\ 7.9 - 45;\ 7.7 - 62\}$ Soils of high, medium pH, and medium L%.

$C = \{1;\ 4;\ 5;\ 8 \mid 6.2 - 78;\ 5.6 - 50;\ 5.6 - 71;\ 6.5 - 70\}$ Soils of low, medium pH, and medium, high L%.

With a phosphorus rate of 280 mg the elements of groups A, B and C show a close interconnection. The a and b parameters increase simultaneously and result in a group order A, B, C (Table 2). The a parameters of the soil groups characterize the L%, the *b* parameters the pH values of the soils (Table 4).

With a phosphorus rate of 28 mg in the *a* parameter the elements of groups A and C show a close, and those of group B a satisfactory interconnection. In the *b* parameter the interconnection between the elements of groups B and C is unambiguous, while those of group A show a scattered arrangement. With the parameters the agreement of $a \to$ pH, $b \to$ L% is good.

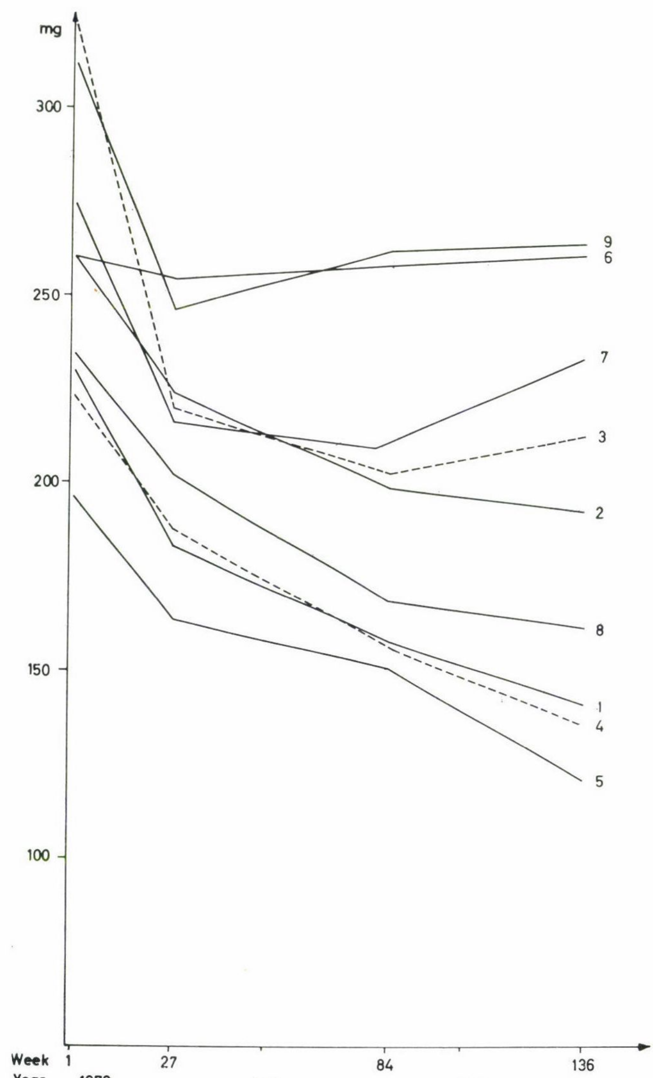

Fig. 1. Temporal change of AL-soluble phosphorus content in soils with an application of 280 mg P_2O_5/100 g soil

With a phosphorus dose of 2.8 mg, in the case of parameter *a* the same holds for groups A and C as with a phosphorus dose of 28 mg, while the elements of B are dispersed. In parameter *b* the interconnection between the elements of B and C is only just recognizable, while the elements of group A fall wide apart. Here the agreement of $a \rightarrow$ pH is perfect, while that of $b \rightarrow$ L% is only partial.

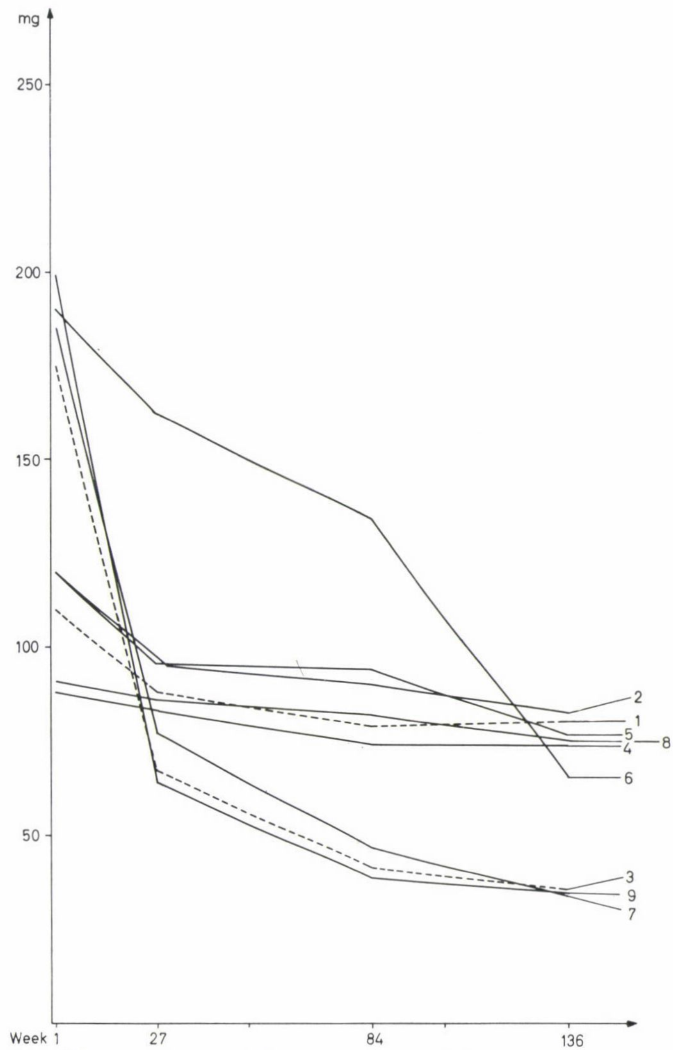

Fig. 2. Temporal change of OLS-soluble phosphorus content in soils with an application of 280 mg P_2O_5/100 g soil

Table 2

Increasing order of the a and b parameters of functions in the model using AL as solvent

When function $y = \frac{1}{a + bx}$, $d = 280$ mg P_2O_5/100 g soil									
Number of soil	9	3	6	2	7	8	1	4	5
$a = a_i \cdot 10^{-3}$	3.48	3.55	3.77	3.98	3.99	4.49	4.62	4.65	5.16
$s_a = s_{a_i} \cdot 10^{-4}$	2.97	4.79	0.93	1.66	4.16	2.11	2.48	1.36	2.35
pH	7.8	7.9	7.9	6.7	7.7	6.5	6.2	5.6	5.6
L %	53	45	11	50	62	70	78	50	71
Number of soil	6	9	7	2	3	8	5	1	4
$b = b_i \cdot 10^{-5}$	0.099	0.36	0.59	1.04	1.32	1.55	1.94	1.56	2.00
$s_b = s_{b_i} \cdot 10^{-6}$	1.19	4.13	6.09	2.73	8.79	3.77	4.34	4.80	2.64
pH	7.9	7.8	7.7	6.7	7.9	6.5	5.6	6.2	5.6
L %	11	53	62	50	45	70	71	78	50
When function $y = a \cdot e^{-bx}$, $d = 28$ mg P_2O_5/100 g soil									
Number of soil	1	4	8	5	2	7	9	6	3
$a = a_i \cdot 10^{0}$	14.31	16.24	17.71	18.47	19.42	21.62	27.06	38.33	38.96
$s_a = s_{a_i} \cdot 10^{-1}$	14.9	15.9	7.16	13.5	8.33	6.67	20.4	2.75	2.79
pH	6.2	5.6	6.5	5.6	6.7	7.7	7.8	7.9	7.9
L %	78	50	70	71	50	62	53	11	45
Number of soil	7	6	3	2	4	9	5	1	8
$b = b_i \cdot 10^{-3}$	0.23	0.33	0.60	1.11	1.75	1.96	2.65	3.08	3.41
$s_b = s_{b_i} \cdot 10^{-4}$	3.86	0.90	0.91	5.66	13.4	10.4	10.6	15.6	6.20
pH	7.7	7.9	7.9	6.7	5.6	7.8	5.6	6.2	6.5
L %	62	11	45	50	50	53	71	78	70
When function $y = a - bx$, $d = 2.8$ mg P_2O_5/100 g soil									
Number of soil	1	8	2	4	5	7	9	6	3
$a = a_i \cdot 10^{0}$	2.16	2.76	4.22	4.93	5.15	6.66	7.86	13.40	16.44
$s_a = s_{a_i} \cdot 10^{-1}$	1.55	0.61	6.19	2.03	1.71	3.57	2.75	4.93	5.01
pH	6.2	6.5	6.7	5.6	5.6	7.7	7.8	7.9	7.9
L %	78	70	50	50	71	62	53	11	45
Number of soil	6	4	2	5	9	1	8	7	3
$b = b_i \cdot 10^{-3}$	−8.77	−6.17	−4.94	−3.79	−1.12	+0.13	3.80	5.39	6.51
$s_b = s_{b_i} \cdot 10^{-3}$	6.08	2.50	7.64	2.11	3.39	1.92	0.75	4.41	6.19
pH	7.9	5.6	6.7	5.6	7.8	6.2	6.5	7.7	7.9
L %	11	50	50	71	53	78	70	62	45

Table 3

Increasing order of the a and b parameters of functions in the model using Olsen's solvent

When function $y = \frac{1}{a + bx}$, $d = 280$ mg P_2O_5/100 g soil									
Number of soil	**9**	6	**7**	**3**	*8*	*2*	*1*	5	4
$a = a_i \cdot 10^{-3}$	4.73	5.09	5.18	5.45	8.58	8.78	9.33	10.99	11.42
$s_a = s_{a_i} \cdot 10^{-4}$	3 60	5.62	2.82	4.01	5.34	5.60	7.05	1.67	2.47
pH	7.8	7 9	7.7	7.9	6 5	6.7	6.2	5.6	5.6
L %	53	11	62	45	70	50	78	71	50
Number of soil	5	4	2	8	1	6	7	3	9
$b = b_i \cdot 10^{-5}$	1.76	1.86	2.86	3.24	3 36	4.57	24.19	27.98	32.46
$s_b = s_{b_i} \cdot 10^{-5}$	0 25	0.37	0.99	0.99	1.29	1.63	3.84	6.11	7.79
pH	5 6	5.6	6.7	6.5	6.2	7.9	7.7	7.9	7.8
L %	71	50	50	70	78	11	62	45	53
When function $y = a \cdot e^{-bx}$, $d = 28$ mg P_2O_5/100 g soil									
Number of soil	*1*	*2*	4	*8*	5	**7**	**9**	**3**	6
$a = a_i \cdot 10^{0}$	9.64	11.31	11.42	12.09	12.59	13.48	15.66	18.92	20.97
$s_a = s_{a_i} \cdot 10^{-1}$	6.47	8.46	12.1	4.29	2.94	6.89	27.4	48.9	38.6
pH	6.2	6.7	5.6	6.5	5.6	7.7	7.8	7.9	7.9
L %	78	50	50	70	71	62	53	45	11
Number of soil	4	2	5	1	7	8	3	9	6
$b = b_i \cdot 10^{-3}$	0.83	1.20	2.34	2.36	2.81	3.68	4.59	6.88	7.14
$s_b = s_{b_i} \cdot 10^{-4}$	13.7	9.91	3.32	9.56	7.53	5.55	42.9	34.4	36.9
pH	5.6	6.7	5.6	6.2	7.7	6.5	7.9	7.8	7.9
L %	50	50	71	78	62	70	45	53	11
When function $y = a - bx$, $d = 2.8$ mg P_2O_5/100 g soil									
Number of soil	*1*	*2*	*8*	**9**	**7**	4	6	**3**	5
$a = a_i \cdot 10^{0}$	1.96	2.23	2.36	2.87	3.07	3.55	3.79	3.99	4.18
$s_a = s_{a_i} \cdot 10^{-1}$	1.99	2.31	1.47	2.83	2.76	2.22	5.57	2.07	2.77
pH	6.2	6.7	6.5	7.8	7.7	5.6	7.9	7.9	5.6
L %	78	50	70	53	62	50	11	45	71
Number of soil	9	3	7	4	1	5	2	6	8
$b = b_i \cdot 10^{-3}$	−7.83	−7.12	−3.69	−3.61	−3.17	−2.86	−2.47	−0.12	2.04
$s_b = s_{b_i} \cdot 10^{-3}$	3.49	2.55	3.41	2.74	2.46	3.42	2.85	6.87	1.81
pH	7.8	7.9	7.7	5.6	6.2	5.6	6.7	7.9	6.5
L %	53	45	62	50	78	71	50	11	70

Table 4

Size of parameters a and b and of pH and L% in the three groups using AL as solvent

Dose			280 mg		28 mg		2.8 mg	
Parameter								
Group	pH	L%	*a*	*b*	*a*	*b*	*a*	*b*
A	high	medium low	low	high medium	high	medium low	high	medium low
B	high medium	medium	medium	high medium	high medium	medium low	high medium	high medium
C	medium low	high medium	high	medium low	low	high	medium low	high medium low

In the case of Olsen's solvent:

A = {6 | 7.9 — 11} Soils of high pH and low L%.
B = {1; 2; 8 | 6.2 — 78; 6.7 — 50; 6.5 — 70} Soils of medium and low pH, and medium to high L%.
C = {4; 5 | 5.6 — 50; 5.6 — 71} Soils of low pH, and medium to high L%
D = {3; 7; 9 | 7.9 — 45; 7.7 — 62; 7.8 — 53} Soils of high pH and medium L% value.

With a 280 mg rate of phosphorus fertilization in the *a* and *b* parameters the elements of all groups show a close interconnection, and the groups are sharply separated (Table 3). Apart from parameter *a* in group D and *b* in group A, the agreement of *a* → L% and *b* → pH is perfect (Table 5).

In the case of a 28 mg dose of phosphorus the elements of all groups are closely related in parameter *a*, while in parameter *b* the elements of C.

Table 5

Size of parameters a and b and of pH and L% in the different groups using Olsen's solvent

Dose			280 mg		28 mg		2.8 mg	
Parameter								
Group	pH	L%	*a*	*b*	*a*	*b*	*a*	*b*
A	high	low	high	medium low	high	high	high	high
B	medium low	high medium	medium	medium	medium low	medium low	high low	high medium
C	low	high medium	high	low	medium low	medium low	high medium	medium
D	high	medium	low	high	high	high medium	high medium	medium low

and D show a medium, and those of B a considerably weakening interrelation. The agreement of $a \rightarrow pH$ and $b \rightarrow L\%$ is fully displayed by parameter a in groups A and D, not at all by b in group A, and partly by the other parameters.

With a dose of 2.8 mg phosphorus, in the a parameter group B shows a close, and A, C and D a relatively loose connection, while in parameter b all groups show a close interconnection of the elements. The requirement of $a \rightarrow pH$, $b \rightarrow L\%$ is fully met by the a parameter in group A and by the b parameter in group B, not at all by b in group A and a in C, and only partly by the other parameters not mentioned so far.

Computer observations. For curve fitting we modified the CURFIT programme from the programme collection of the MTA SzTAKI CDC-3300 machine, since the original programme has the disadvantage of being highly sensitive to what initial parameters are given and is consequently very difficult to start up. If the initial values are not suitably chosen the iteration will not converge. It is useful to include a subroutine to calculate the initial parameters from the measured data of x_i, y_i depends on the process under examination and the number of parameters. In the present case a good result was obtained with initial parameters calculated from the value of the function determined at the point $x_i = 10$ on the line connecting the y_i values corresponding to dates $x_i = 1$ and 27, as well as from function values measured in the $x_i = 84$th week.

Table 6 is a results board where x and y are the measured x_i and y_i values,

FUNCTION (hereafter f) the values of function $y = \dots$,
ABS. DIFF. $= y - f$
REL. DIFF. $= \dfrac{y-f}{f}$

(*) WEIGHTED VARIANCE $= \dfrac{\sum_{i=1}^{n} w_i (y_i - f_i)^2}{n-k}$ where n is the number of points measured, k the number of variable-fixed parameters.
VARIANCE = (*) if $w_i = 1$, $(i = 1, \dots, n)$
PARAM 1 $= a$
PARAM 2 $= b$

Let us see which theoretical values outside the h_1 and h_2 limits differ significantly from σ, the actual standard deviation of parameters a and b at a given P% probability level. From PRÉKOPA's (1974) first thesis it follows that, assuming a mass with a distribution of N (m, σ), $\dfrac{n-1}{\sigma^2} \cdot s^2$ is also a random variable with $n - 1$ degrees of freedom and a distribution of χ^2.

Table 6

Results board of soil No. 8 using AL solvent. Regression function: $y = a \cdot e^{-bx}$, phosphorus application: 28 mg

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POINT	$X(1)$	Y	FUNCTION	ABS. DIFF.	REL. DIFF.
1	1.000000E 00	1.750000E 01	1.765255E 01	−1.525483E-01	−0.009
2	2.700000E 01	1.680000E 01	1.615168E 01	6.483170E-01	.040
3	8.400000E 01	1.260000E 01	1.329283E 01	−6.928298E-01	−0.052
4	1.360000E 02	1.190000E 01	1.112854E 01	7.714601E-01	.069

INVERSE OF P MATRIX

6.763467E-01	4.001710E-04
4.001710E-04	5.062348E-07

VARIANCE	= 7.593749E-01	WEIGHTED VARIANCE	= 7.593749E-01
PARAM 1	= 1.77129797E-01	STANDARD ERROR	= 7.16659E-01
PARAM 2	= 3.41753468E-03	STANDARD ERROR	= 6.20018E-04

Thus, the confidence limits for the standard deviations of error can be given by the formulae (SVÁB 1973):

$$h_1 = s\sqrt{\frac{FG}{\chi^2_{\frac{p\%}{2}}}} \quad \text{and} \quad h_2 = s\sqrt{\frac{FG}{\chi^2_{100\% - \frac{p\%}{2}}}}.$$

In the present case FG = 14, since method (1) used 15 different parameters. At a P = 5% probability of error $h_1 = 0.732 \cdot s$ and $h_2 = 1.577 \cdot s$, while at P = 2% $h_1 = 0.693 \cdot s$ and $h_2 = 1.733 \cdot s$, where s represents the standard deviations s_a and s_b in Tables 2 and 3, respectively.

Agrochemical observations. At the time $x = 0$, function (4) assumes the form $y = \frac{1}{a} = a'$, while functions (5) and (6) assume the form $y = a$. Parameter a thus indicates the AL- or $NaHCO_3$-soluble phosphorus content measured at the point of time $x = 0$, and has the dimensions mg P_2O_5/100 g soil. It can be seen that the parameter thus obtained gives the initial values of the respective functions. It should be noted that after phosphorus application the readily soluble phosphorus content shows a similar behaviour to that of the labile phosphorus; namely, a few hours after the phosphorus is introduced into the soil a comparative equilibrium is set up. A change in this equilibrium, the transformation of labile phosphorus into a non-labile form, however, takes much more time, months or even years. The first analysis was performed a week after the phosphorus application so the mathematical correlations given previously did not describe the change of solubility taking place in the first hours. From a practical point of view, the slower changes are primarily of importance. Accordingly, the value determined at the point of time $x = 0$ is only the initial value of the slower change, which is described by the functions.

Tables 2 and 3 show that the values a and a' rise with the amount of phosphorus applied, and this increase is related to the pH and the mechanical structure of the soil (L%). For the three phosphorus doses examined and for both solvents it holds true that soils of higher pH and coarser texture have higher a values than the heavier soils with lower pH.

Parameter b, included in functions (4), (5) and (6), gives the decrease of solubility per unit time. Its dimensions are mg P_2O_5/week, and it is accordingly called the velocity constant for the decrease in solubility. As seen from Tables 2 and 3, b is primarily pH-dependent; further, this pH dependence turns out to be of opposite meaning with the two solvents. When AL is used as solvent high pH soils show lower values for b, whereas with $NaHCO_3$ higher b values are obtained in high pH than in low pH soils. In other words, the AL-soluble phosphorus content decreases at a much slower rate in high pH carbonate soils than in low pH soils lacking carbonates. The decrease of the $NaHCO_3$-soluble phosphorus content, on the other hand, is much more rapid in the high pH carbonate soils than in lower pH soils not containing carbonates. This is seen particularly in the case of the 280 mg phosphorus application. Phosphorus doses applied in practice range from 2.8 to 28 mg P_2O_5/100 g soil.

According to experimental data not given here in detail, the faster rate of decrease in the $NaHCO_3$-soluble phosphorus contents in high pH carbonate soils can be explained by the fact that the readily soluble calcium phosphates formed under the influence of phosphorus application are transformed comparatively quickly into less soluble calcium phosphates. While the former phosphorus compounds dissolve in a solution of $NaHCO_3$, the latter do not. By contrast, the AL solvent dissolves both types of phosphate compound. It is due to this that in carbonate soils the $NaHCO_3$-soluble phosphorus content decreases at a much faster rate than the AL-soluble content. In soils not containing carbonate, although there is a difference in the rate at which the solubility determined with the two solvents decreases, it is not usually significant.

In the course of further investigations the following questions may arise: which of the solvents gives the best indication of the change in the phosphorus content available to the plant? Is it possible to give a mutually unambiguous transformation between parameter a (parameter b) and the pH- value or sedimentable part (L%) of the soils, or between a linear combination of the latter two?

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A NEW METHOD FOR DETERMINING SELF-FERTILITY IN PLUM VARIETIES

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The author has examined 17 self-fertile, 7 partially self-fertile, 7 practically self-sterile and 23 self-sterile plum varieties. On the basis of the length of pistil, number of functional stamina, the quotient of these (SN/PL) and the average length of internode he found differences between the fertility groups. Pistils are the longest in partially self-fertile and somewhat shorter in self-fertile plum varieties; self-sterile and practically self-sterile varieties are characterized by short pistils. The situation is reversed as regards the number of stamina: self-sterile plum varieties have the largest number of stamina. The examination of varieties by group has confirmed that the quotient is suitable for characterizing the extent of self-fertility: the quotient of partially self-fertile varieties is lower than optimum (1.84 pc/mm), while in practically self-sterile and self-sterile varieties the quotient ranges between 2.24 and 2.35 pc/mm, i. e. the relative number of stamina is higher than optimum. The value of the quotient is the numerical expression of sexual correlation. On the basis of 1620 flowers, there is a significant negative correlation between pistil length and the number of functional stamina. In a mid-summer survey of shoots, we found a correlation demonstrable at a 2% level between the quotient and the average length of internode ($r = +0.259$). Finally, the quotient and the average length of internode in the shoots are parameters apparently suitable for characterizing the self-fertility of plum. The method is simple and easy to apply, so that a large number of plum varieties, prospective varieties (selected or introduced), hybrids or perhaps rootstock populations can be examined within a short time.

Introduction

From a comprehensive evaluation of 122 varieties published by DAHL (1935), many new results have been obtained in the course of data processing. There are substantial differences between the self-fertile, partially self-fertile and self-sterile plum varieties in the length of peduncle, length of pistil, and size of sepals and petals. A close positive correlation has been found between the length of peduncle and length of pistil.

TÓTH (1975) is perfectly right when, in opposition to RÉMY (1954) and RÖDER (1940), he doubts whether the relative position of the anther and the stigma is characteristic of the fertility conditions.

This conception has recently been revived by GRZYB—ZAGAJA (1975), though the actual value of their paper is given by the examination of flower structure as a function of the rootstock. There is a positive correlation between stylus length and fruit setting, that is, the good rootstocks are those on which the "Olasz kék" flowers have longer pistils.

TÓTH (1957) made observations on nearly 100 varieties for several years. In this and later publications (TÓTH 1967, 1968), he demonstrated that the self-fertility of plum varieties is a genetically fixed feature. From TÓTH's (1957) result a further conclusion can be drawn, namely, that the petiole is significantly longer in self-sterile than in self-fertile and partially self-fertile varieties, and is thus a selective character.

HASKELL—DOW (1955) and MORRISON (1964) reported that the number of stamina is a constant character hardly modified by climatological factors and geographical situation. MORRISON (1964) gave a survey of the genus *Prunus*; according to our own calculations for the genus, the ploidy level and the number of stamina show a negative correlation.

TÓTH (1975) gave a full summarization of the fertility relations of plum varieties. The "Alutscha" I/15 clone is female sterile as indicated by the length of the flower peduncle (SURÁNYI—TÓTH 1976), while other varieties (e.g. "Esperen aranyszilvája", "Kék datolya", "Tulen gras") are male sterile. Most self-sterile plums are auto-incompatible; inter-incompatibility can be pointed out in only a few cases TÓTH 1975).

The opinion of KOBEL (1954) and TÓTH (1975) is confirmed by the investigations carried out at Cegléd. The relative number of stamina (quotient) has proved to be more suitable for characterizing the fertility relations than the interrelation of anthers and pistil. A high value of the quotient (number of stamina per 1 mm of pistil) suggests that the variety in question is self-sterile (SURÁNYI 1970, 1971a).

In the meantime the quotient in some species has been found to be low (the flowers are of feminine character, e.g. almond, almondpeach), while in others it is very high (the flowers are of masculine character, e.g. sweet and sour cherry, mahaleb). On the basis of the quotient not only the species but also the varieties can be typified (SURÁNYI 1974).

This phenomenon can be explained by the close negative correlation demonstrable between the macro- and microphyll; the regression trend is much sharper in self-fertile than in self-sterile varieties (SURÁNYI 1973).

Twin-pistilled forms (bicarpy), the polyphylly of the pistil (polycarpy) (e.g. Kirke) and a smaller or larger extent of staminal phyllody (staminodia) can easily be explained by the sexual correlation (SURÁNYI 1972). The relation of shoot and flower organization in the varieties "Besztercei szilva" and "Jeruzsálemi kék" is biometrically demonstrable (SURÁNYI 1971b).

On the basis of examinations performed by RESENDE (1967) on *Bryophyllum* the vegetative character of flower organs seems to differ, decreasing in the order calyx → gynoeceum → corolla → androeceum. The sepal has the strongest shoot character of all, but the pistil is also more like a shoot than are the petals and stamina. In fact, influences advantageous to the growth processes exert a favourable effect primarily on the size of the sepals and on the size and number of pistils. For example: we found that alpha-naphthylacetic acid treatment on "Besztercei szilva" and monilia infection to "Magyar kajszi" trees increased the female character of the flowers (SURÁNYI 1975, 1977). In the latter case the mycelia introduce a stimulator called sclerotinine into the apricot trees.

In the present paper a summary is given of the sexual relations of plum varieties, which is of considerable importance from the point of view of variety evaluation (methodology) and selection (breeding).

Material and method

The flowers were collected and the surveys were made according to a method previously described in detail (SURÁNYI 1970, 1973, 1974). The pistil length was measured in 30 completely open flowers of each of 54 plum varieties and the functional stamina in each flower were counted. The number of stamina per 1 mm of pistil length, i.e. the quotient, was obtained by simple division.

On 14th July 10 shoots were collected from each plum variety and the average length of the internodes was determined from the length of the shoot and the number of internodes.

From the point of view of self-fertility, the varieties showed the following distribution: 17 were found to be self-fertile, 7 partially self-fertile, 7 practically self-sterile and 23 self-sterile; in classifying the varieties, we relied on the results obtained by TÓTH (1975).

The pistil length, stamen number, quotient and internode length of the plum varieties were evaluated by analysis of variance, and from the averages of the varieties further calculations were made with a varying number of replications.

The study includes a total of 1620 flower data; the frequency distribution for pistil length and stamen number was also examined. We used the Chi^2-test to check whether the basic data of sexual correlation really show a normal distribution.

The correlation of pistil length and stamen number for each flower was determined by linear regression analysis; the r-values obtained from the Chi^2-test and the equation of the linear correlation were almost identical, so no non-linear regression analysis was performed.

An important objective of our work was to study the relationship between shoot and flower organization. It was for this reason that we calculated the correlation between the quotient and the average length of internode for the 54 varieties, since if a correlation of this kind could be pointed out, the length of the internode might also be of importance in selection.

Results

The data of the 54 plum varieties examined are shown in Table 1, according to the categories set up by TÓTH (1975). In the self-fertile plum varieties pistil length and stamen number show a considerable variation, while the quotient is fairly steady. In the varieties "Besztercei szilva" and "Besztercei muskotály" the relative number of stamina is remarkably low; in the other self-fertile varieties the quotient ranges from 1.70 to 2.66 pc/mm.

The small number of partially self-fertile varieties appears to be insufficient to characterize the group, but it may certainly be noted that the relative stamen number of these plum varieties is less than that of the self-fertile ones. The number of stamina is generally low in the flowers of the 7 varieties, with the single exception of "Lőweni szép", as is clearly reflected in the quotient.

The average length of the internode is highest in the partially self-fertile plum varieties as compared to the other three groups.

The practically self-sterile varieties have the shortest pistils of all, a relatively large number of stamina, and consequently a high quotient value. A remarkably low variation is shown by the length of the internode, which ranges from 1.81 to 2.58.

The self-sterile plum varieties, 23 in number, made a thorough analysis possible. Besides varieties with extremely short pistils, the pistils of some varieties in this group are long. In the varieties "Pacific", "Vörös nektarin" and "Washington" the number of stamina is less than 23, while in the other varieties it exceeds this number. Extraordinarily low quotients were obtained in the varieties "Pacific" and "Washington". The length of the internode is more than 2 cm in most self-sterile plum varieties, except for two ("Alutscha" and "d'Italia") which have decidedly short internodes (Table 1).

We have mentioned in several publications the necessity of examining the quotient for applicability in practice. For this purpose we thought it best to make a comparison between the quotient values obtained and the self-fertility data. Pistils are the longest in the partially self-fertile and somewhat shorter in the completely self-fertile varieties. In the self-sterile varieties the pistils are not significantly shorter than in self-sterile plums, but are more fully developed in comparison to those of the practically self-sterile varieties.

The number of functional stamina is never identical in the groups. The partially self-fertile and self-fertile varieties have fewer stamina, while the number of stamina is substantially larger in the practically self-sterile and self-sterile plums. The quotient showed remarkably large differences between the groups: self-fertile and partially self-fertile varieties, and self-fertile and self-sterile varieties showed differences in the relative number of stamina only at a 10% level, while in the other cases differences can be demonstrated at a level of at least 5%.

Data on the average internode lengths in the four groups were also processed; the length of the internode in the varieties was not found to be consistent in every respect. The partially self-fertile varieties have the longest internodes, followed by the practically self-sterile ones. Between self-fertile and self-sterile plum varieties no reliable difference in the average length of the internodes can be demonstrated (Table 2).

Before determining the sexual correlation we wished to know whether the data on pistil length and stamen number showed a normal distribution. On the basis of the Chi^2-test normal distribution can be accepted as a fact (Chi^2 = 91.20 and p = 0.1%) (Fig. 1), so even in the case of a significant r-value any mistake in sampling is out of the question.

The average pistil size and the stamen number are strikingly similar in the four groups (the average values are marked with x). This in it self

Table 1

Data on flowers of plum varieties (1976)

Varieties	Pistil length, mm	Stamen number, pc	Quotient SN/PL, pc/mm	Internode length, cm
Self-fertile varieties				
Wangenheimi	12.40	24.10	1.95	1.67
Vörös szilva	10.80	27.30	2.56	2.23
Walesi herceg	12.73	27.63	2.18	2.40
Ontario	10.50	27.80	2.66	2.64
Ageni 1.	12.30	28.43	2.33	2.36
Kék úri	10.93	22.03	2.06	1.59
Besztercei muskotály	15.23	18.17	1.27	1.49
Besztercei szilva	14.44	18.33	1.29	1.76
Sárga mirabella	10.87	28.37	2.62	1.79
Bühli korai	11.53	19.50	1.70	2.07
Tarka perdrigon	12.90	28.07	2.21	2.19
Milánói császár	13.03	30.27	2.34	1.75
Letricourt	14.07	23.93	1.71	2.09
Egger Gusztáv	13.33	27.60	2.08	2.50
Bosznia királynője	9.93	21.40	2.18	1.79
Angoulème-i	14.10	25.40	1.81	2.04
Olasz kék	14.63	26.33	1.81	2.26
Partially self-fertile varieties				
Nagy cukor	14.23	24.00	1.68	1.95
Englebert	15.10	22.63	1.50	2.21
Leppermann Emma	12.23	22.33	1.84	2.68
Lőweni szép	14.23	29.10	2.07	3.03
Gömöri nyakas	9.07	23.47	2.64	2.64
Violaszínű ringló	13.67	25.13	1.84	2.21
Beregi datolya	13.63	18.90	1.39	1.84
Practically self-sterile varieties				
Sötétkék tojás	10.17	26.93	2.66	2.25
Nagyherceg	11.03	27.23	2.49	1.81
Zöld ringló	11.27	26.90	2.42	2.21
Primate	13.00	34.07	2.63	2.21
Sasbachi korai	11.27	18.60	1.66	2.26
Ruth Gerstetter	11.93	23.73	2.00	2.06
Althann ringló	10.90	28.07	2.59	2.58

(Table 1 continued)

Varieties	Pistil length, mm	Stamen number, pc	Quotient SN/PL, pc/mm	Internode length, cm
Self-sterile varieties				
Alutscha	10.03	26.80	2.71	1.14
Áttetsző ringló	11.37	29.67	2.63	1.62
Burdett Angelina	10.97	30.37	2.78	2.56
Cochet	12.60	26.10	2.06	1.93
Columbia	12.63	26.10	2.09	2.10
Dániel szilva	11.27	24.67	2.19	1.61
Di Francforte	10.57	27.57	2.63	1.74
d'Italia	13.53	26.73	1.98	1.28
Jodoigne	11.17	26.83	2.44	2.11
Késői muskotály	11.70	28.73	2.49	1.66
Kirke	12.27	29.37	2.38	2.24
Mirabellák királynője	11.33	27.93	2.50	2.36
Montfort	11.07	27.77	2.53	2.30
Nancyi ringló	11.23	26.77	2.39	2.37
Pacific	14.13	17.63	1.26	2.20
Pond magonca	14.23	32.57	2.31	2.55
Prince piros	15.53	27.77	1.80	2.30
Sárga tojás	14.50	27.40	1.89	2.28
Sárga úri	10.87	28.37	2.61	2.41
Späth legkorábbi	11.00	24.57	2.25	2.39
Tragédia	12.97	28.33	2.20	2.48
Vörös nektarin	11.73	22.77	1.95	2.19
Washington	15.73	22.60	1.58	2.20
LSD 5%	0.466	1.43	0.141	0.085

Table 2

Summary of flower examinations in four fertility groups

Groups	Pistil length, mm	Stamen number, pc	Quotient SN/PL, pc/mm	Internode length, cm
Self-fertile[1]-(a)	12.56 c	24.98 d	2.04 c	2.03 b
Partially self-fertile[2]-(b)	13.16 c	23.64 cd	1.85 cd	2.36 ad
Practically self-sterile[3]-(c)	11.36 ab	26.50 b	2.35 ab	2.18
Self-sterile[4]-(d)	12.31	26.83 ab	2.24 a	2.09 b
LSD 5%	0.342	1.77	0.221	0.218

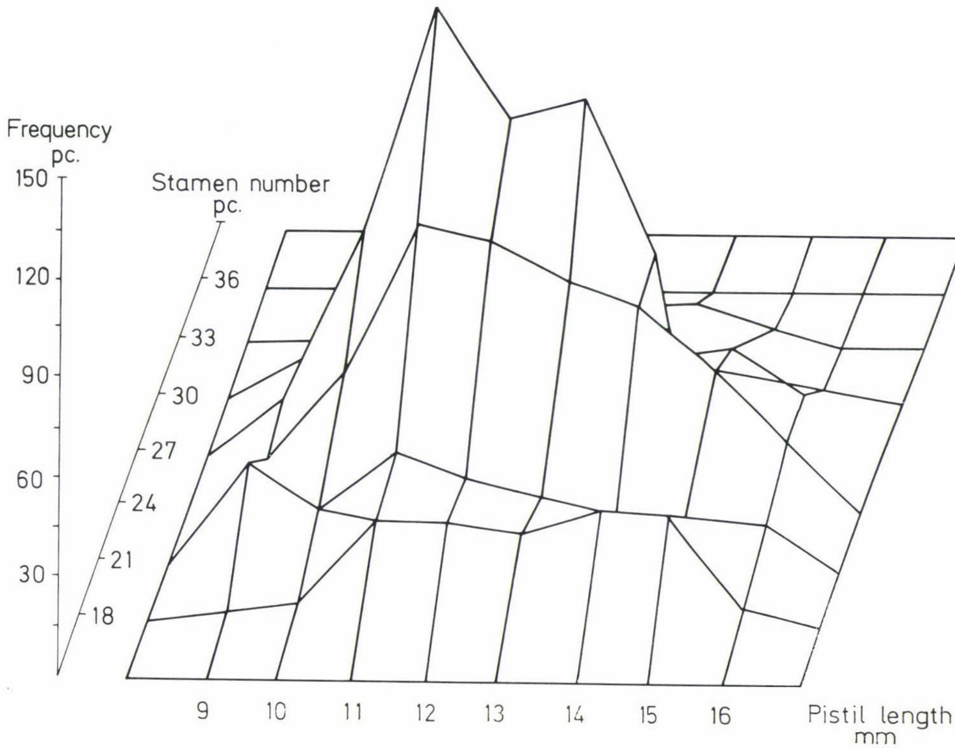

Fig. 1. Spatial diagram of pistil length and stamen number ($n = 1620$)

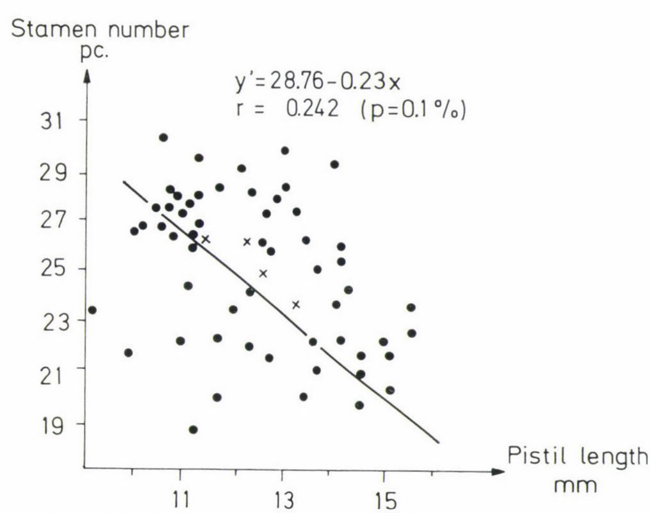

Fig. 2. Correlation of sex organs of plums and gage varieties

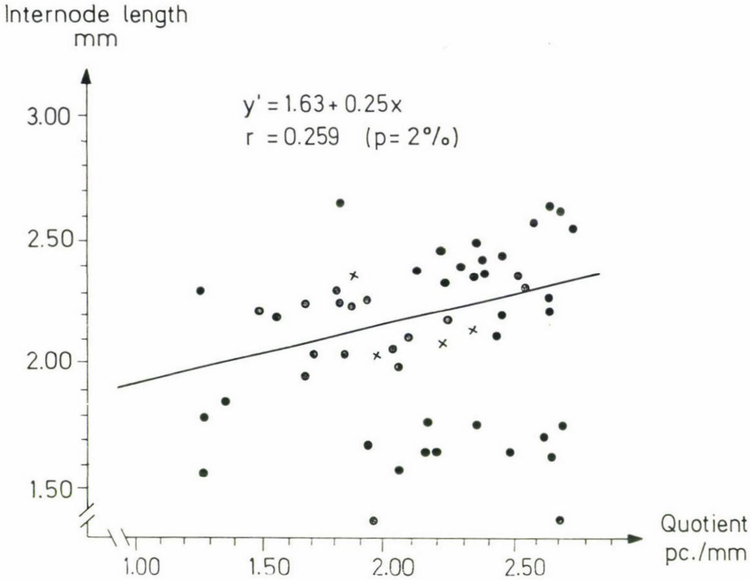

Fig. 3. Relationship of quotient (SN/PL) and internode length in plums and gage varieties

suggested a negative correlation between the length of the pistil and the number of functional stamina. The regression trend is valid for the varieties examined with an error margin of 1% (Fig. 2).

The discovery of the correlation between flower and shoot organization was definitely the most exciting part of our work. The quotient, i.e. the relative number of stamina, showed a positive correlation with the length of the internode (Fig. 3).

Discussion

In the literary review mention was made of many highly important works which deal with the fertility of plum varieties. RUDLOFF—SCHANDERL (1950) state in their book that plum varieties are quite different as regards fertility: there are male sterile, female sterile, auto-incompatible and inter-incompatible varieties.

Sterility may be of morphological or genetic origin; the latter occurs less frequently in plum. From the results reported by MORRISON (1964), it is clear that the ploidy level is in negative correlation with the number of stamina. The relationship between macro- and microsporophylls is easier to describe and prove than the correlation between the sexual organs. However, RÉMY (1954) demonstrated a positive correlation between pollen diameter and stylus length.

WELLINGTON *et al.* (1921) attributed great importance to the structure of the flower; recent investigations have not, however, confirmed their views.

The dominance relations known in shoots also hold true for the flower organs. The gynoeceum corresponds to the terminal shoot, the stamina are equal in value to the laterals; the main, or sexual correlation is thus the relation between the gynoeceum and the androeceum, while the secondary correlation is the relation between sepals and petals (SURÁNYI 1974).

A clear view of self-sterility has recently been given by ARASU (1968) and LUNDQVIST (1975), while for plum varieties important results have been published by TÓTH (1975). The self-fertility of plum can be influenced by the rootstocks (GRZYB—ZAGAJA 1975), pruning and synthetic auxins (SURÁNYI 1977). Alpha-naphthyl acetic acid potassium salt increases the phyllody of the stamina, but this change has a detrimental effect, because the self-fertility of the treated trees will thus decrease.

Most of the varieties included in the present study follow the trend of sexual correlation; this trend is sharper in the self-fertile than in the self-sterile varieties, i.e. the change in pistil length does not exercise the same effect on the number of stamina in the two groups.

As to the length of the internode in the different varieties, unambiguous results have not yet been obtained, but even from the quotient it can be seen that the relative stamen number of ideally self-fertile varieties can be approximated by an optimum curve, that is, too high and too low quotient values only occasionally make a sufficient extent of self-fertility possible. Some varieties conspicuously differ from the rest of their group, such as: "Besztercei szilva", "Besztercei muskotály", "Beregi datolya", "Sasbachi korai", "Pacific" and "Washington".

To sum up, there is a significant difference in quotient between the self-fertile (totally and partially) and self-sterile (practically and completely) varieties; the relative stamen number is higher in self-sterile than in self-fertile plums. Differences in the length of the internode were less reliable, even when a correlation was found between the quotient and the length of the internode.

Further, it may be mentioned that some plum varieties (those that deviate greatly from the average characteristic of their respective groups) show a negative correlation between the quotient and the length of the internode. On the basis of nine years' experience the quotient definitely seems to be suitable for characterizing the fertility conditions of the species, variety or clone; however, it would be much better if a conclusion could be drawn on the fertility of the examined tree from the internode length of year-old shoots, so that pre-selection could be carried out at an earlier date and with a simpler index.

In earlier years 5 plum varieties were examined over four years; in the varieties "Besztercei szilva", "Olasz kék", "Zöld ringló", "Prince piros" and "Jeruzsálemi kék" the length of the pistil and the number of stamina showed a slight fluctuation (though following the sexual correlation in each case), while the quotient proved to be decidedly stable. The quotient was in close correlation with the self-fertility percentage.

The quotient and the length of the internode depend on the endogenous hormone conditions; the high stimulator level enhances the female character. while an increase in the proportion of inhibitors causes masculinization (RESENDE 1967). We specified three self-fertile plum varieties: "Besztercei szilva", "Besztercei muskotály" and "Bosznia királynője". In the first two varieties the overdeveloped gynoeceum had an adverse effect on the androeceum: it resulted in the phyllody of 1—3 stamina per flower, a reduced ability for pollen tube formation, and finally a fertility percentage greatly varying from clone to clone. The fertility of the plum variety "Bosznia királynője" could apparently be increased with growth stimulators.

The results obtained for the self-sterile varieties are not unambiguous, mainly due to the fact that from an empirical point of view varieties of masculine and feminine character were each placed in one group. Further, investigations are required to overcome these difficulties.

The current work will be continued, as with this method the evaluation of varieties, introduced varieties, prospective varieties, hybrids and rootstock populations could be greatly accelerated. Furthermore, it may be of help in demonstrating the good and bad consequences of chemical treatments.

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BREEDING SPRING BARLEY FOR STANDING ABILITY

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The standing ability of the Martonvásár spring barleys has been examined for many years by evaluating the extent of lodging in the field, measuring the plant height, calculating the ratio of grain yield/lodging, establishing the leaf surface per stem and determining the Complex Standing Ability Index (CSAI). The crossing partners suitable for improving the standing ability and its components have been noted. The standing ability of the Martonvásár spring barley varieties decreases in the following order: Mv 46, Mv 43, Mv 45, Mv 48, MK 42, MK 47 and Mv 41.

Introduction

The rising level of mechanization, the increasing rate of fertilization, and in general, the intensification of agricultural production render it necessary to breed malting barley for higher stalk strength. In the experiments of Rodger (1956), Kurillov (1957), Kopeczky (1969), Aganovic—Miletic (1972), Peev (1972), Gardener—Rathjen (1975) and others lodging reduced the grain yield of spring barley by 15—50%, and in nitrogen fertilization trials by 63—66%, depending on various circumstances. Furthermore, lodging considerably reduced the brewing quality of barley (Sowinski 1963, Roebers 1964, Ulonska 1964, Dubetz—Wells 1968, Welling 1975, etc.). Breeders consider the improvement of standing ability as one of the most important tasks, and are continually elaborating new methods of examination and selection (Uctum—Hungerbrühler 1968, Was 1970, Pollhamer 1971, Ragasits 1971, Garkaviy—Nazarenko 1972, Schulzke *et al.* 1974).

Material and method

At the Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvásár, regular breeding for standing ability has been carried out on spring barley stock and varieties by evaluating the extent of natural lodging. On the average of 12 years the lodging value of spring barley was 1.77 (Fig. 1).

In some years, e.g. in 1968, 1969 and 1973, lodging did not occur. From 1964 to 1967 there was very little opportunity to select for standing ability, since the extent of lodging in those years was medium or low, with a relatively low variation coefficient. Ample possibility of selection for standing ability was offered in 1970, when a low lodging average was accompanied by a high degree of lodging in some combinations, with a very high variation coefficient.

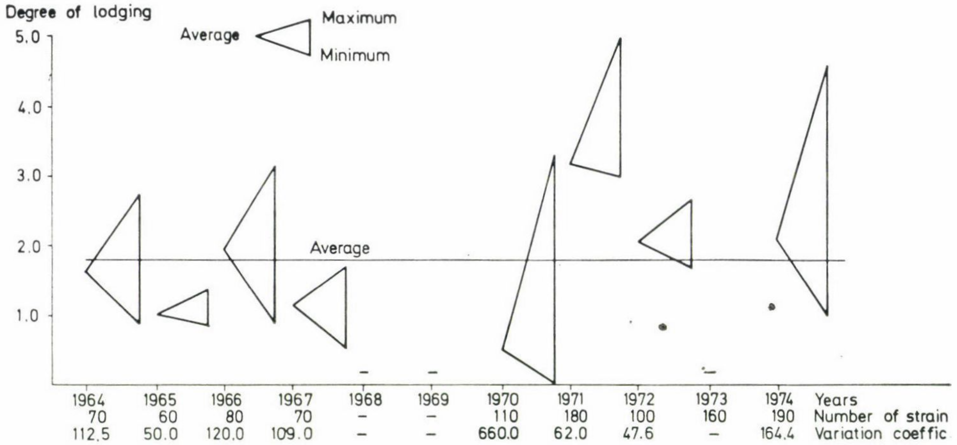

Fig. 1. Average, maximum and minimum of lodging in a spring barley trial. Martonvásár 1964—1974

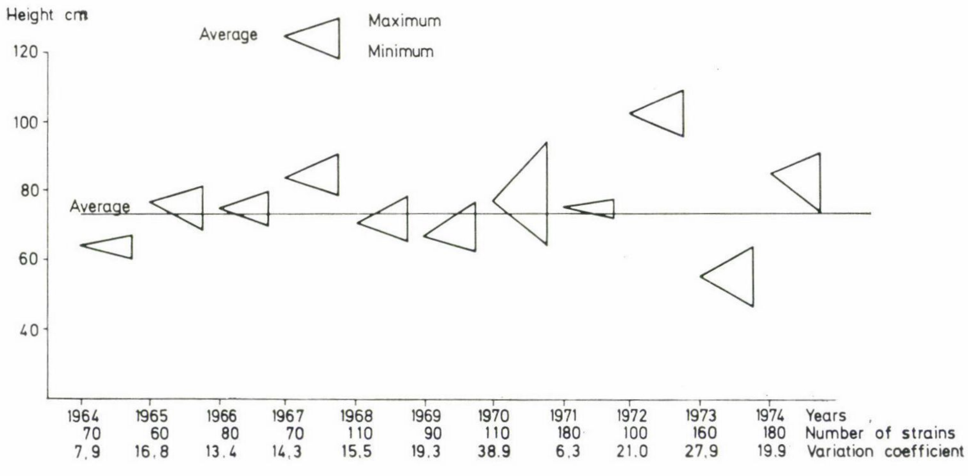

Fig. 2. Average, maximum and minimum heights in an experimental spring barley breeding stock. Martonvásár 1964—1974

A similar opportunity for selecting for straw stiffness arose in 1971, when the lodging average was very high and the variation coefficient medium, and again in 1974 with a medium lodging average and a high variation coefficient. In those three years we were able to separate the strong-strawed combinations, strains and varieties from those inclined to lodge. However, the evaluation of natural lodging can only be carried out occasionally, so the breeder has to adopt methods which provoke lodging.

Lodging depends to a great extent on the height of the plant. Breeders improve the standing ability of the breeding stock mainly by selecting for short straw. The 12 years' plant height average (74 cm) in the Martonvásár spring barley breeding stock is primarily the result of systematically breeding for short straw (Fig. 2), though some role was also played by the weather, which has been unfavourable for the development of barley in recent years.

Results

On the basis of the results of a series of measurements and the evaluation of the progeny of crossing combinations the following spring barley varieties have been found to be suitable for reducing the plant height and increasing the stiffness of stalk: Alva, Amethyst, Aramir, Astacus, Berac, DB 1364, Hanna M_2, HE 593, Hor 1251, Hor 1252, Mamie, Maris Mink, Menet, Midas, Mona, Miln's 155, Minerva II, Osijek 57/61, Simba, Senat, Sv 65505, Sv 66302 and Sv 66433. The standing ability of some short-strawed varieties is only seemingly better and is mostly based on lateness, since late varieties evaluated at the same stage of development always seem more strong strawed than early varieties of the same height.

From the point of view of standing ability selection for short straw is useful only down to a certain plant height. Below a certain limit the short stalk is usually accompanied by yield depression. Such varieties provide less shade, and consequently certain weeds, e.g. horse-thistle, may overgrow the stand (Otto 1973).

The extent of lodging is greatly influenced by the volume of grain yield. The ratio of grain yield/lodging is a characteristic measure of standing ability (Table 1). Grain yield, lodging value and the grain yield/lodging ratio are remarkably good in the varieties and combinations Mv 46, MKH 23, Mv 45 and Mv 43. The order of standing ability for MKS 61, MKS 83, MK 380 and MKH 228 is better when based on the grain yield/lodging ratio than when established by the extent of lodging. This means that under identical lodging conditions these combinations give larger yields than the other varieties. The combination MKS 99, as well as the varieties in the variety trial and the hybrids in the hybrid trial, lodge even with a lower than average grain yield, so they may be classified as being inclined to lodge.

Lodging is greatly influenced by the surface area and position of leaves on the stalk (Pollhamer 1967, 1974, 1975). In our experiments the leaf surface of spring barleys was 45.7 cm^2 with a variation coefficient of 111.1%. In the varieties MK 301, MK 42, MKH 23, Certa, Maris Mink and MKS 99 the leaf surface was greater than 50 cm^2, while in Carmen, MKS 26, Tern, Mona, W. Wing and Amkar T 444 it was less than 40 cm^2.

Under Hungarian conditions varieties with large grain yields, small leaf areas and short, firm stalks are considered the most valuable. By regular selection for these characters the standing ability of spring barleys can be considerably increased.

Besides the above, many other factors may influence the extent of lodging. All factors cannot be taken into consideration in selection. To characterize the standing ability for the purpose of selection, we have introduced the Complex Standing Ability Index (CSAI) (Pollhamer 1967, 1971, 1975). The CSAI

Table 1

Average lodging in spring barley combinations Martonvásár, 1974—1975

Combination	Grain yield q/ha			Lodging value			Ratio of grain yield/ lodging	Order	
	1974	1975	Mean	1974	1975	Mean		by lodging value	by ratio
Mv 46	62.8	—	62.8	1.1	—	1.1	57.0	1	1
MKH 23	59.2	—	59.2	1.1	—	1.1	53.8	2	2
Mv 45	70.2	52.9	61.5	1.6	1.2	1.4	43.9	3	3
Mv 43	57.8	52.5	55.1	1.7	1.4	1.5	36.7	4	4
Local stock trial	—	48.3	48.3	—	1.7	1.7	28.4	5	5
MKS 61	67.3	43.3	55.3	1.9	2.4	2.1	26.3	8	6
Awnless barleys	51.3	48.3	49.8	1.9	1.9	1.9	26.2	6	7
MKS 83	51.9	—	51.9	2.1	—	2.1	24.7	9	8
MKS 99	—	46.5	46.5	—	2.0	2.0	23.2	7	9
MK 380	57.4	—	57.4	2.5	—	2.5	22.9	12	10
MKH 228	67.1	49.0	58.0	2.8	2.6	2.7	21.4	13	11
Variety trial	41.8	46.6	44.2	1.4	2.8	2.1	21.0	10	12
MK 42	63.8	45.1	54.4	2.6	2.9	2.7	20.1	14	13
Variety trial	62.8	44.6	53.4	2.7	2.7	2.7	19.7	15	14
Mv 44	61.9	—	61.9	3.5	—	3.5	17.6	17	15
Mv 48	62.2	48.1	55.0	2.0	4.4	3.2	16.1	16	16
Hybrid trial	—	32.5	32.5	—	2.2	2.2	14.7	11	17
Average	59.8	46.4	53.36	1.70	1.65	2.14	27.86	—	—
Var. coeff.	31.2	43.8	34.85	205.88	266.66	112.14	15.18	—	—

is determined by a graphic illustration of the values for 8 components of standing ability, and by planimetry on the obtained polygon. The stalk weight and the number of nodes are directly proportional to the standing ability, while the degree of lodging, the stalk length, the length of the uppermost internode, the 5 minute water uptake of the straw, the average length of the internodes and the leaf area on the stalk are inversely proportional to the standing ability.

The CSAI and its components are suitable for characterizing the standing ability of the varieties, for carrying out selection for standing ability, for choosing the right crossing partners, for planning and bringing about new firm-stalked combinations, and even for characterizing the effects of agrotechnical treatments, e.g. nitrogen top dressing. For example, a 40 kg/ha nitrogen top dressing applied in addition to basic fertilization of 140 kg/ha NPK reduced the CSAI of the Martonvásár varieties and prospective varieties

Table 2

CSAI in Martonvásár spring barleys Martonvásár, 1964–1974

Components	MK 42 64–74	MK 47 64–74	Mv 41 64–74	Mv 43 72–75	Mv 45 72–75	Mv 46 73–75	Mv 48 74–75	Standard	Mean	Var. coeff. %	40 kg/ha N	
											mean	var. coeff. %
Lodging value	3.0	3.2	3.2	2.2	1.8	2.0	2.7	3.0	2.5	56.0	4.2	28.2
Straw weight, g	1.7	1.5	1.7	2.5	1.6	2.7	1.4	1.5	1.8	72.2	2.0	54.7
Straw length, cm	85.0	90.0	82.2	82.2	68.8	75.6	80.2	70.0	80.5	26.3	86.7	37.9
Number of nodes	5.4	5.7	5.9	6.3	5.5	6.0	5.3	5.5	5.7	17.5	5.8	18.9
Length of upper internode, cm	24.0	27.2	26.2	23.6	21.9	21.7	21.8	20.0	23.7	22.7	26.3	24.3
Water uptake by the stem	19.2	25.2	27.3	15.8	16.2	17.5	28.2	20.0	21.3	58.2	27.5	64.7
Average length of internodes, cm	15.7	15.7	13.9	13.0	12.5	12.6	15.1	15.0	14.1	21.4	14.9	20.5
Leaf area per stalk, cm^2	58.5	61.2	81.0	60.0	67.0	57.7	62.0	60.0	63.9	35.9	78.6	57.7
CSAI	53.9	35.7	33.8	69.3	60.2	97.5	53.1	44.0	55.9	—	—	—
CSAI with 40 kg/ha N top dressing	31.5	28.7	29.5	54.2	48.3	64.7	32.5	44.0	—	—	36.4	—

from 55.9 to 36.4 cm^2 (Table 2). The effect, though varying in its extent, was unequivocal in all varieties. The varieties Mv 46, Mv 43 and Mv 45 showed the highest standing ability and were the most tolerant to nitrogen overdosage, as their CSAI was even then higher than the standard 44.0 cm^2. The nitrogen overdosage had an unfavourable effect on almost all components of the CSAI, leaving only the number of nodes and the stalk weight practically unaffected.

On the basis of our data the standing ability of the Martonvásár spring barley varieties and prospective varieties can be characterized as follows:

The outstanding standing ability of the prospective variety Mv 46 is based primarily on its short, many-noded, heavy stalk. Nitrogen top dressing can be safely applied to it as the decrease in its CSAI is of very low extent.

The variety Mv 43 is of similar type, but its CSAI, i.e. standing ability, is lower than that of the previous variety. This variety also proved to be sufficiently tolerant to nitrogen top dressing, and its CSAI was even then better than the standard.

Mv 45, a spring fodder barley combination, owes its good standing ability mainly to its short, many-noded stem. With nitrogen top dressing its CSAI corresponds to the standard.

Mv 48 is a prospective spring malting barley variety of medium standing ability, with average components. Only its stalk length comes close to the optimum. With nitrogen top dressing its standing ability is not satisfactory.

MK 42 is a malting barley of average standing ability. Its internodes, particularly the upper one, are longer than necessary, so it will not tolerate top dressing.

The spring fodder barley MK 47 has poor standing ability owing to the fact that its upper internode is too long and that a large amount of water is taken up by the stalk; it often shows intensive lodging even without nitrogen top dressing.

The spring malting barley Mv 41 is again of poor standing ability owing to its very large leaf area, its water uptake and the long upper internode. With nitrogen top dressing its CSAI was the lowest of all.

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IDENTIFICATION OF TRANSLOCATIONS IN WHEAT VARIETIES MIRONOVSKAYA 808 AND RANNYAYA 12

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Analyzing the P.M.C.s of crosses between each of 21 monosomic lines of Chinese Spring with Mironovskaya 808 and Rannyaya 12, it was found that two reciprocal translocations, involving chromosomes 3A and 3B on the one hand, and chromosomes 1B and 2D on the other, differentiate Mironovskaya 808 from Chinese Spring. Rannyaya 12 is presumed to have one translocation, involving chromosomes 1B and 2D relative to Chinese Spring. Frequency of P.M.C.s with trivalents and quadrivalents in crosses of the wheat varieties studied was relatively low.

Introduction

Varieties of hexaploid wheat ($2n = 6x = 42$) frequently differ by one or more reciprocal translocations. By hybridizing with species of diploid and tetraploid wheat varieties it was concluded that Chinese Spring has the primitive chromosome structure of hexaploid wheat (SEARS 1954, RILEY *et al.* 1967): the chromosomes of all other hexaploid wheat varieties can, therefore, be compared with those of Chinese Spring. A number of chromosomal interchanges have been identified relative to Chinese Spring (SEARS 1953, RILEY—KIMBER 1961, BAKER—MCINTOSH 1966, RILEY *et al.* 1967, RÖBBELEN 1968, METTIN 1969, LAW 1971, LARSEN 1973, ZELLER 1973, ZELLER—BAIER 1973, BAIER *et al.* 1974).

The presence of translocations among wheat varieties can complicate the development of monosomic and whole chromosome substitution lines (MORRIS—SEARS 1967, LAW—WORLAND 1973). Their presence can also cause problems in the localization of genes to specific chromosomes by means of monosomic analysis (SEARS 1953, UNRAU *et al.* 1956, LARSEN 1973, BAIER *et al.* 1974).

Material and method

Both Mironovskaya 808 and Rannyaya 12 are Russian winter wheat varieties. Mironovskaya 808 was selected from the autumnized progeny of the spring variety Artemovka at Mironovka (REMESLO 1972). Rannyaya 12 has common breeding origin with the variety Bezostaya 1.

In the present research, chromosome pairing in pollen mother cells (P.M.C.s) at the first meiotic metaphase was analyzed in hybrids between each of 21 monosomic lines of Chinese

Spring used as female parents, with Mironovskaya 808 and Rannyaya 12. Disomic hybrids between these three varieties were also analyzed cytologically. The F_1 plants were grown under optimal field conditions at Martonvásár. The somatic chromosome number of the monosomic lines of Chinese Spring and the monosomic F_1 crosses, as well as the meiotic chromosome pairing from spikes of monosomic and disomic F_1 plants, were determined by the Feulgen method.

Results

Two quadrivalents, or one trivalent plus one quadrivalent, were observed in some P.M.C.s from crosses of Chinese Spring with Mironovskaya 808. These observations indicated that these varieties probably differ by two reciprocal translocations. In the crosses between Chinese Spring with Rannyaya 12 on the one hand, and in the crosses between Mironovskaya 808 with Rannyaya 12 on the other, only cells having either one quadrivalent or one trivalent were observed, indicating that each of these varieties differ by one translocation.

The frequency of trivalents and quadrivalents in P.M.C.s of all the crosses was relatively low, and the quadrivalents showed chain configurations. This may indicate that the translocations present in these varieties involve relatively short segments of chromosomes. The percentage of trivalents and quadrivalents in each of these three crosses is highest in F_1 plants of Chinese Spring $\times$ Mironovskaya 808, and lowest in those of Chinese Spring $\times$ Rannyaya 12 (Table 1).

The percentage of P.M.C.s with a single trivalent without any univalent was used for identifying chromosomes involved in the translocations. From Table 2 it can be seen that four F_1 monosomic lines of Chinese Spring $\times$ Mironovskaya 808, 3A, 3B, 1B and 2D produce this type of chromosome configuration. Furthermore, the proportion of cells having trivalents only appear to differ among the four critical monosomic F_1's, those for chromosomes 3A and 3D giving higher frequencies than those for chromosomes 1B and 2D. This difference suggests that one of the translocations may involve chromosomes 1B and 2D.

Table 1

Chromosome pairing at metaphase I in F_1 plants

Hybrid combinations	No. of plants	No. of cells	Number of cells			% of univalents	% of multivalents
			with univ.	with univ. and multiv.	with multiv.		
CS $\times$ Mir. 808	20	137	48	6	7	39.42	9.49
CS $\times$ Ran. 12	25	201	53	2	3	27.36	2.49
Mir. 808 $\times$ Ran. 12	9	193	23	1	9	12.44	5.18

Table 2

Chromosome configurations at metaphase I in F_1 plants from crosses of Chinese Spring monosomics with Mironovskaya 808

Monosomics	No of plants	No. of P M C s	Number of cells in each pairing configuration															% of P.M C s with a single trivalent
			II					III				IV					III + IV	
			$20^{II}+1^{I}$	$19^{II}+3^{I}$	$18^{II}+5^{I}$	$17^{II}+7^{I}$	$16^{II}+9^{I}$	$19^{II}+1^{III}$	$18^{II}+1^{III}+2^{I}$	$17^{II}+1^{III}+4^{I}$	$16^{II}+1^{III}+6^{I}$	$18^{II}+1^{IV}+1^{I}$	$17^{II}+^{IV}+3^{I}$	$16^{II}+2^{IV}+1^{I}$	$16^{II}+1^{IV}+5^{I}$	$15^{II}+1^{IV}+7^{I}$	$16^{II}+1^{III}+1^{IV}+2^{I}$	
1A	3	65	11	14	6					1		3						
2A	5	35	26	7		1						1						
3A	3	43	19	11	2	1		6	2			2						13.95
4A	3	53	41	7	1							3	1					
5A	4	21	10	6	1	1			1			2						
6A	4	32	21	10								1						
7A	5	56	31	10	3							7	3		1		1	
1B	6	100	77	14	3	1		4				1						4.00
2B	4	46	22	13	4	1			1			4	1					
3B	4	56	23	16	3	1		6	2	1		2	1			1		10.71
4B	5	56	30	21	2		1						2					
5B	8	94	68	21	1							3	1					
6B	3	34	22	5	1							4	2					
7B	4	45	31	6	1				1	1		5						
1D	3	36	26	7								2	1					
2D	7	64	41	13	3			3	1			3						4.68
3D	4	52	31	19								2						
4D	4	55	41	10	3							1						
5D	8	67	49	12								5	1					
6D	3	62	34	18	2	1					1	3	2		1			
7D	6	43	23	15	2				1			1		1				
		1115																

I = univalents
II = bivalents
III = trivalents
IV = quadrivalents

In the F_1 monosomic plants of Chinese Spring × Rannyaya 12, two monosomic lines (1B and 2D) were found with a single trivalent without any univalent, and the frequency of the interchange was very low. So, it can be supposed that chromosomes 1B and 2D are involved in the chromosomal interchanges which distinguish Rannyaya 12 from Chinese Spring.

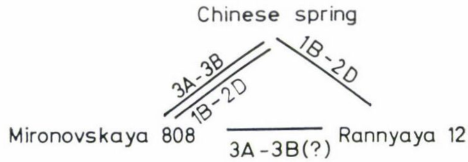

Fig. 1. Diagram showing the interchanges by which the three wheat varieties under investigation are differentiated

The high frequency of P.M.C.s with 3, 5 or 7 univalents in F_1 monosomics of Chinese Spring with Mironovskaya 808 can presumably be an acceptable explanation for the high frequency of univalent shift which was observed in the course of developing a monosomic set of Mironovskaya 808 at Martonvásár (unpublished).

The interchange relationship between the three varieties studied is shown in Fig. 1. Although the frequency of the interchanges between Chinese Spring and Rannyaya 12 was found to be lower than that between Mironovskaya 808 and Rannyaya 12, the translocation involving the 3A and 3B (which probably differentiates the Mironovskaya 808 from Rannyaya 12 cytologically) needs to be checked later. This will be possible when the development of a monosomic series of these varieties has been completed at Martonvásár.

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VARIA

EFFECT OF THE SIZE OF BLOCK ON THE AMOUNT OF FRUIT IN PEAR VARIETIES

Pear varieties grown in Hungary are completely self-sterile. It is not every year nor in all varieties, however, that natural parthenocarpy provides satisfactory fruit setting. Pear varieties should, therefore be, planted in every case together with pollen donor varieties of mutually high fertility, blossoming at the same time and ensuring ample overlapping.

The ability of fructification in pear varieties can be assessed by the percentage of fruit setting, too. In richly blossoming trees a 3 per cent fruit setting results in a large yield, while those of poorer flowering require 15—20 per cent fruit setting.

In pears, wind is a factor of practically no importance in pollen transmission; pollination is mainly carried out by wild bees and wild insects. Wind plays a role in pollen transmission in the case of small distances (6—8 m), between trees next to one another, because with an increasing distance pollen density decreases and so the probability of pollination will be very low. For self-fertile fruit varieties pollination by wind has a complementary role, as in this case pollen even within the same tree is effective.

When choosing pollen donor varieties for pears a fundamental consideration is to what extent, they are attractive for the insects and how much pollen they are able to discharge under unfavourable ecological conditions (e.g. in cool, rainy weather).

Pollen donor varieties and the method and rate of plantation for pears should be chosen taking into consideration the time of flowering, conditions of fructification, ripening time and picking operations, as well as the purpose for which the fruit will be used.

The present paper analyzes the effect of block size on the yield of pear varieties.

In the course of the investigation, we wished to receive an answer to the following questions: 1.) How does the amount of fruit change as a function of the distance from the pollen donor variety? 2.) What are the trends of fruit yield in varieties planted in various proportions and patterns? 3.) What is the effect of the size of block on the amount of fruit?

Data were collected in 1973 on the State Farm at Kutas, in a plantation of-14-years old spindle trees grafted to quince root-stock "A" with a spacing of 7.5×4.5 m. The plantation consisted of three varieties: Téli esperes, Hardy vaj and Hardenpont téli vaj, which are early, medium early and late flowering, respectively.

The varieties were planted in close spaced blocks of different width. The arrangement of the blocks can be seen in Fig. 4 and Table 2.

To study the effect of the pollen donor varieties, we chose blocks of such width and position as would exclude the participation of pollen from other varieties in the pollination. In the blocks marked out for this purpose, the amount of fruit per tree was measured at different distances from the pollen donor variety. By using the yield results thus obtained we formed blocks in which the varieties were found in different proportions and arrangement in order to be able to find out the joint effect of the two factors on the amount of fruit. In the plantation fruit yield was also determined for each block with a view to assessing the joint effect of block size and arrangement on the amount of fruit.

Fruit yield of pear varieties as a function of the distance from the pollen donor is shown in Figs 1—3.

The effect of the distance of "Hardy vaj" and "Hardenpont téli vaj" pollen donor varieties on the amount of fruit in the pear variety "Téli esperes" in seen in Fig. 1.

The average fruit yield per tree in the pear variety "Téli esperes" was 55, 46 and 38 kg at a distance of 7.5, 15 and 22.5 m, respectively, from the pollen donor variety "Hardy vaj". In the next two rows the amount of fruit decreased to half (27 kg at a distance of 30 m and 25 kg at 37.5 m). The quantity of fruit per tree was 5.2 kg at a distance of 7.5 m from the row of "Hardenpont téli vaj", and 4.5 kg at 15 m.

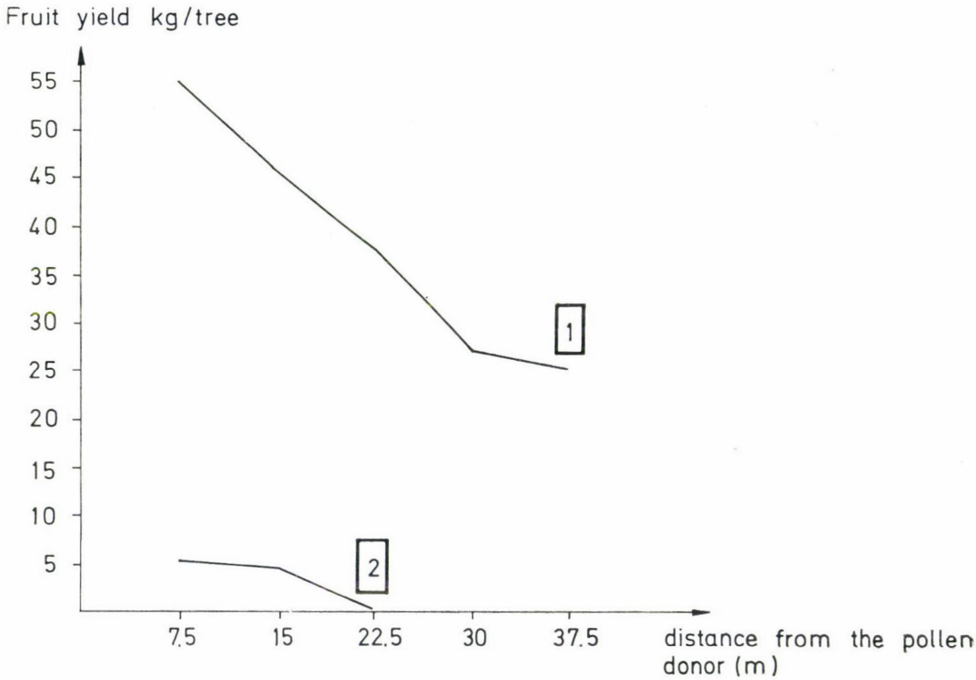

Fig. 1. Effect of the distance of "Hardy vaj" and "Hardenpont téli vaj" pollen donor pear varieties on the amount of fruit in the variety "Téli esperes" (1973, Kutas)

The effect of the distance of the pollen donor varieties "Hardenpont téli vaj" and "Téli esperes" on fruit yield in "Hardy vaj" can be seen in Fig. 2.

The fruit yield of the pear variety "Hardy vaj" was 68 kg at a distance of 7.5 m from the row of "Téli esperes" and decreased to 37 kg at 37.5 m. In rows planted at a distance of 7.5 m from the pear variety "Hardenpont téli vaj" the quantity of fruit per tree showed the following trend: 32, 25, 15, 13 kg, and in the fifth row 11 kg.

The effect of distance from the pollen donor varieties "Téli esperes" and "Hardy vaj" on the fruit yield of the variety "Hardenpont téli vaj" is shown in Fig. 3.

The amount of fruit per tree in the variety "Hardenpont téli vaj" was 15.5 kg at a distance of 7.5 m from the row of "Téli esperes", while only 4 kg when the distance was 37.5 m. At a distance of 7.5 from the row of the pollen donor variety "Hardy vaj" the quantity of fruit per tree was 47.5 kg; at distances of 30 and 37.5 m the corresponding values were 32 and 25 kg, respectively.

The effect exerted on the fruit yield per tree and per hectare of pear varieties planted in rows in different rates and patterns can be analyzed on the basis of data shown in Table 1.

The amount of fruit is the lowest in blocks where the pear varieties "Téli esperes" and "Hardenpont téli vaj" are found, as e.g. in block A (30.6 q/ha) where the varieties "Téli esperes" and "Hardenpont téli vaj" were planted in alternating rows at a ratio of 1 : 1.

In blocks containing the varieties "Hardy vaj" and "Hardenpont téli vaj" an increase in the amount of yield can be observed. The smaller the width of block of the two varieties, the

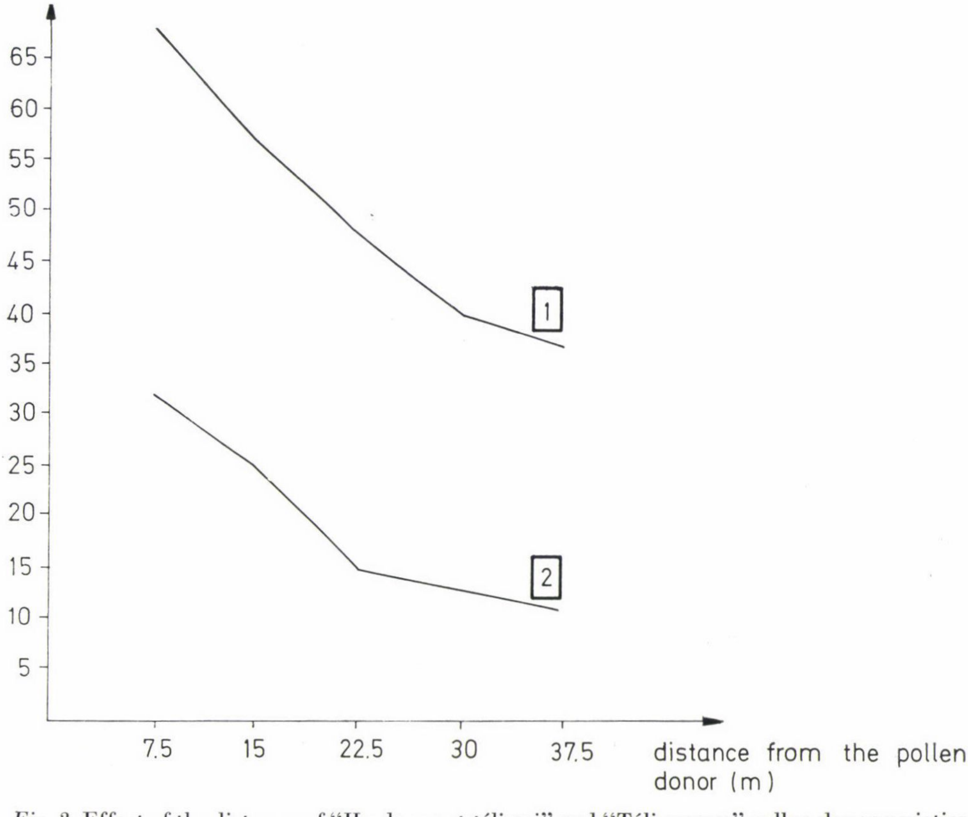

Fig. 2. Effect of the distance of "Hardenpont téli vaj" and "Téli esperes" pollen donor varieties on the amount of fruit in the pear variety "Hardy vaj" (1973, Kutas)

larger the yield. In block K (a ratio of 1 : 1; one row of "Hardy vaj", one row of "Hardenpont téli vaj") the yield per hectare was 117.7 q. In block M, in the case of the varieties "Hardy vaj" and "Hardenpont téli vaj" planted at a ratio of 1 : 2 (one row of Hardy vaj, two rows of "Hardenpont téli vaj") the average yield was 125.1 q/ha.

In blocks where the varieties "Téli esperes", "Hardy vaj" and "Hardenpont téli vaj" were contained the yield per ha ranged between 138 and 168.2 q according to the ratio and arrangement of the varieties. Deviation from this value only occurred in blocks E and L, where the ratio of the varieties was similar, but, due to the different size of block (10 and 5 rows per variety, respectively), the quantity of fruit was smaller (E = 84.7 q/ha; L = 123.2 q/ha).

The amount of yield was the largest in block V (182 q/ha) where the varieties "Téli esperes" and "Hardy vaj" were found at a ratio of 1 : 1 (one row of "Téli esperes", one row of "Hardy vaj"). The effect of block size can be pointed out even in the case of a 1 : 1 ratio of the two varieties. For example, the 159.3 q/ha yield of a 37.5 m wide block (block N).

In the pear orchard the three varieties ("Hardy vaj", "Téli esperes", "Hardenpont téli vaj") are found in a total of 18 blocks of different size. Fruit yields for each block are shown in Table 2, while the effect of block size and arrangement can be studied in Fig. 4.

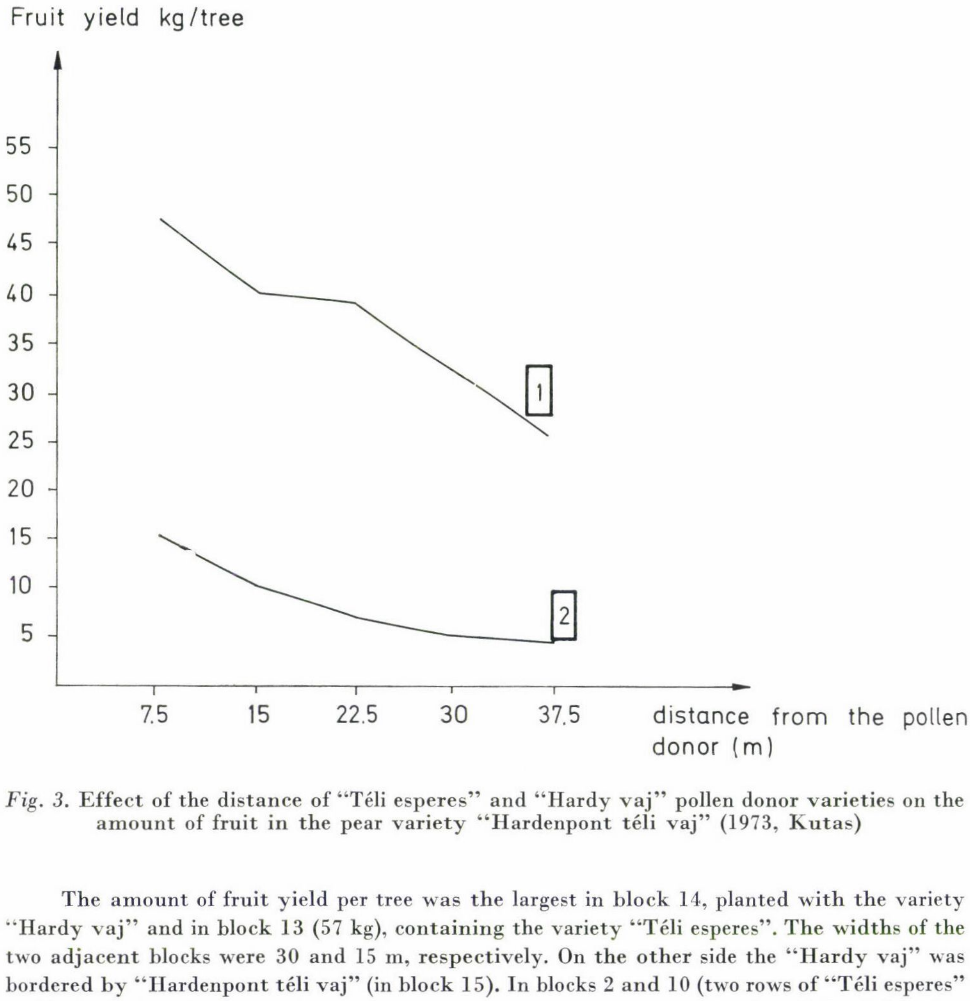

Fig. 3. Effect of the distance of "Téli esperes" and "Hardy vaj" pollen donor varieties on the amount of fruit in the pear variety "Hardenpont téli vaj" (1973, Kutas)

The amount of fruit yield per tree was the largest in block 14, planted with the variety "Hardy vaj" and in block 13 (57 kg), containing the variety "Téli esperes". The widths of the two adjacent blocks were 30 and 15 m, respectively. On the other side the "Hardy vaj" was bordered by "Hardenpont téli vaj" (in block 15). In blocks 2 and 10 (two rows of "Téli esperes" each) the fruit yield was 53 kg per tree; this lower quantity was due to the width of the adjacent "Hardy vaj" block. Block 7 produced the smallest amount of fruit (4.8 kg/tree) where three rows of "Téli esperes" were bordered by a ten-row block of "Hardenpont téli vaj" on both sides. The two end blocks of the plantation contained "Hardenpont téli vaj". In block 18 the amount of fruit per tree was 20.6 kg; in this case "Hardy vaj" was the adjacent pollen donor. In block 1 bordered by the variety "Téli esperes" 8.2 kg was the fruit yield per tree. Fig. 4 reveals similar correlations.

Table 1

Effect of different ratios and patterns of pear varieties planted in rows on fruit yield in spindle-tree plantation spaced at 7.5×4.5 m (1973, Kutas)

Block	Arrangement of rows in the block	Variety									Yield q/ha
		"Téli esperes"			"Hardy vaj"			"Hardenpont téli vaj"			
		proportion, %	tree number	yield	proportion, %	tree number	yield	proportion, %	tree number	yield	
			ha	kg/tree		ha	kg/tree		ha	kg/tree	
A	1 row Téli esperes 1 row Hardenpont	50	148	5.2				50	148	15.0	30.64
B	1 row Téli esperes 3 rows Hardenpont	25	74	5.2				75	222	13.9	34.7
C	10 rows Hardy 5 rows Hardenpont				66	196	19.2	34	100	42.8	80.43
D	10 rows Hardy 10 rows Hardenpont				50	148	19.2	50	148	36.6	82.49
E	10 rows Téli esperes 10 rows Hardy	34	100	28.7	33	98	34.6	33	98	22.5	84.66
F	6 rows Hardy 3 rows Hardenpont				66	196	24.0	34	100	45.0	92.04
G	5 rows Hardy 5 rows Hardenpont				50	148	25.8	50	148	42.8	101.52
H	2 rows Hardy 1 row Hardenpont				66	196	32.0	34	100	47.5	110.12
I	3 rows Hardy 3 rows Hardenpont				50	148	29.7	50	148	45.0	110.56
J	3 rows Hardy 6 rows Hardenpont				34	100	29.7	66	196	41.8	111.63
K	1 row Hardy 1 row Hardenpont				50	148	32.0	50	148	47.5	117.66
L	5 rows Téli esperes 5 rows Hardy	34	100	38.2	33	98	50.0	33	98	36.4	123.17
M	1 row Hardy 2 rows Hardenpont				34	100	32.0	66	196	47.5	125.10
N	10 rows Téli esperes 10 rows Hardy	50	148	38.2	50	148	50.0				130.54
O	4 rows Téli esperes 4 rows Hardy 2 rows Hardenpont	40	118	41.5	40	118	53.2	20	60	43.7	137.97
P	1 row Téli esperes 4 rows Hardy 5 rows Hardenpont	10	30	55.0	40	118	62.5	50	148	42.8	153.59
R	1 row Téli esperes 1 row Hardy 2 rows Hardenpont	25	74	55.0	25	74	68.0	50	148	43.7	155.77
S	5 rows Téli esperes 5 rows Hardy	50	148	48.0	50	148	59.6				159.25
T	2 rows Téli esperes 2 rows Hardy 1 row Hardenpont	40	118	50.5	40	118	62.5	20	60	47.5	161.84
U	1 row Téli esperes 1 row Hardy 1 row Hardenpont	34	100	55.0	33	98	68.0	33	98	47.5	168.18
V	1 row Téli esperes 1 row Hardy	50	148	55.0	50	148	68.0				182.04

Note: In the blocks the varieties are replicated at least once

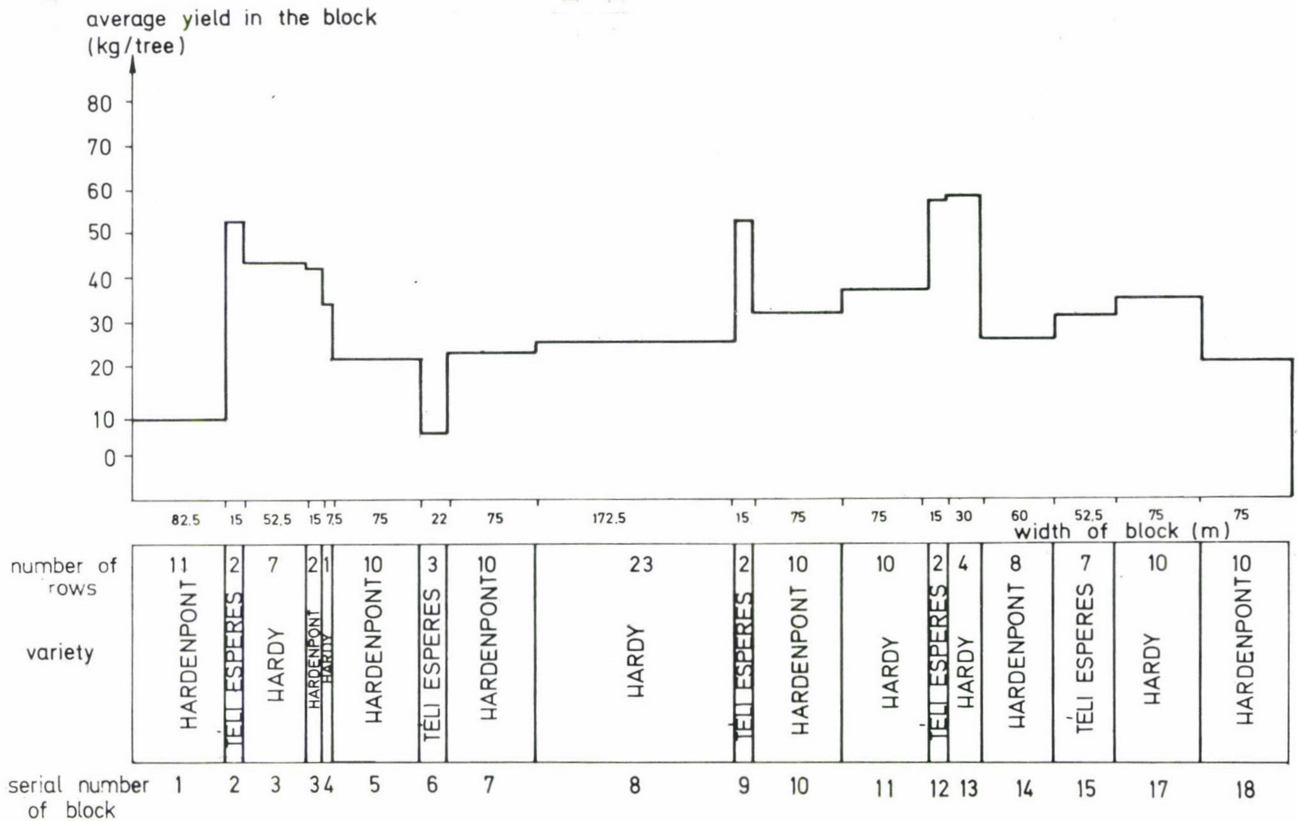

Fig. 4. Effect of width and arrangement of the variety block on fruit yield in pear varieties (1973, Kutas)

Table 2

Arrangement of variety blocks in a pear orchard of 7.5×4.5 m spacing, and amount of fruit per tree in the individual blocks (Length of rows: 515 m) (1973, Kutas)

Serial number of blocks	Variety	Number of rows in the block	Width of row (m)	Average yield in the block (kg/tree)	Rows marked out for distance studies in pollen donor varieties
1.	Hardenpont téli vaj	11	82.5	8.2	
2.	Téli esperes	2	15.0	53.0	
3.	Hardy vaj	7	52.5	44.0	
4.	Hardenpont téli vaj	2	15.0	42.5	
5.	Hardy vaj	1	7.5	35.0	
6.	Hardenpont téli vaj	10	75.0	21.9	Hardenpont t. v. 6—10 rows
					×
7.	Téli esperes	3	22.5	4.8	Téli esperes 1— 2 rows
8.	Hardenpont téli vaj	10	75.0	23.5	Hardenpont t. v. 6—10 rows
					×
9.	Hardy vaj	23	172.5	25.5	Hardy vaj 1— 5 rows
10.	Téli esperes	2	15.0	53.0	
11.	Hardenpont téli vaj	10	75.0	32.2	
12.	Hardy vaj	10	75.0	37.6	
13.	Téli esperes	2	15.0	57.0	
14.	Hardy vaj	4	30.0	58.0	
15.	Hardenpont téli vaj	8	60.0	25.8	
16.	Téli esperes	7	52.5	31.7	Téli esperes 3— 7 rows
					×
17.	Hardy vaj	10	75.0	35.4	Hardy vaj 1— 5 rows
18.	Hardenpont téli vaj	10	75.0	20.6	

The fruit yield per tree shows great fluctuations according to block size and border variety.

On the basis of the results of investigations the following conclusions can be drawn:

— if the flowering times of the varieties do not coincide, fruit setting and fruit yield will not be satisfactory even in the case of the most favourable pollen donor ratio and variety arrangement (e.g. in the combination of "Téli esperes" and "Hardenpont téli vaj").

— The effect of block size on the amound of fruit can only be studied in combinations of simultaneously blossoming, mutually fertile varieties (e.g. "Téli esperes"×"Hardy vaj", or "Hardy vaj"×"Hardenpont téli vaj").

— In the case of self-sterile fruit varieties the width of the variety block should be determined on the basis of the fructification ability of the adjacent pollen donor variety. The wider the block the higher the percentage fructification of the pollen donor variety should be.

— According to our observations in the case of self-sterile, mutually fertile pear varieties the most favourable pollen donor ratio varies with the fructification percentage of the varieties. The ratio of pollen donor to receptor should be 1 : 1 (50—50 per cent) in the case of pear varieties of low fructification, 1 : 2 (33—67 per cent) for varieties of medium, and 1 : 3 (25—75 per cent) for those of high fructification.

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FIVE YEARS' RESULTS OF INVESTIGATIONS INTO POWDERY MILDEW IN WHEAT AT MARTONVÁSÁR (1971—1975). IV. TREND OF DAMAGE CAUSED BY POWDERY MILDEW

The appearance, spread and damage caused by powdery mildew are not unusual events in Hungary. According to PÁTER (1911), in some places in the country which are exposed to infection wheat stands were ploughed up as early as the 1890's owing to the high extent of damage. Nation-wide epidemics did not generally occur, however, so the disease was considered to be insignificant (LINHART 1904, MOESZ 1912, VILLAX 1947, LELLEY—RAJHÁTHY 1955).

Since the end of the fifties, however, wheat growing in Hungary has changed considerably. From the earlier extensive method of cultivation the country has switched over to intensive wheat production which involves a higher rate of fertilization, denser sowing and more careful tending (RAJKI 1960). This creates favourable conditions for the development and spreading of powdery mildew in the wheat stand, all the more so because the varieties used in commercial production are susceptible to the disease.

A powdery mildew epidemic on a national scale first occurred in 1961 (PODHRADSZKY—CSUTI 1962). Since that time powdery mildew has been reckoned with as a regularly appearing pathogen (SZUNICS—SZUNICS—BALLA 1974). The pathogen may cause up to a 20—30% loss (PODHRADSZKY—CSUTI 1964), though the majority of the data show damage of less than 10% (SZUNICS—SZUNICS 1967, HINFNER—SZABÓ 1968, PÁSTI 1972, KOLTAY—BALLA 1975).

The researchers generally established the extent of damage either by inference or by using various chemical treatments. In the latter case, though we obtained certain data, we could not find out what the effect exercised by the chemical on the plants was, whether it caused stimulation or depression. In an earlier experiment, for example, the chemical JF-1230, applied three times in 400 lit/ha water at a concentration of 1.5%, disturbed the physiological balance of wheat (SZUNICS—SZUNICS 1967).

Starting from this, we used varieties heterogeneous for resistance (Kavkaz, Avrora, Bezostaya 2) and hybrid populations (various generations of the combination of RPG 14/44 × Bezostaya 1) for establishing the extent of field damage. The plants were grouped by susceptibility and the losses caused by the infection were assessed on the basis of actual yield data. However, this work had to be discontinued in 1972 as a significant change occurred in the powdery mildew population. With the multiplication of powdery mildew races (particularly races 4, 26 and 52) which attack Kavkaz and other varieties of similar genetic structure, as well as their hybrids, since 1973 these varieties and hybrids have become susceptible (SZUNICS 1976). In 1972 a serious stem rust epidemic occurred, which provided an opportunity to evaluate the varieties and hybrids for resistance to this pathogen as well.

Since powdery mildew may appear in the stands in the autumn or early in the spring it is necessary to know the response given by the young plants to the pathogen. With this in view a greenhouse experiment with four replications was set up on 28th February 1975 with Bezostaya 1, Kavkaz, Martonvásári 2 (susceptible) and Arthur (resistant) as test plants. Three treatments were used: 1 — control (the plants were not inoculated and remained healthy throughout the experiment); 2 — inoculation at the one-leaf stage (10th March); 3 — inoculation two weeks later (24th March). The green plants were harvested on 7th April (100 plants per treatment were weighed). Thus, the number of days from inoculation to harvesting was 0 in the control, 28 in the second treatment and 14 in the third. By the end of the experiment the level of infection in the susceptible varieties reached 100%. In the resistant variety Arthur a few pustules appeared after the inoculation, and the leaves showed an intensive yellowing (chlorosis).

The experimental data prove that the varieties give different responses to infection by the pathogen (Table 1). Bezostaya 1 seems to be a tolerant variety; while no decrease in the

Table 1

Effect of powdery mildew infection on the fresh weight of young plants in 1975 (weights of 4 × 100 plants per treatment)

Variety	Number of days from inoculation	Weight g	Weight %	Loss %
Bezostaya 1	0	53.49	100.00	0.00
	14	57.32	107.16	+ 7.16
	28	39.08	73.06	−26.94
Kavkaz	0	49.04	100.00	0.00
	14	43.48	88.66	−11.34
	28	16.32	33.28	−66.72
Martonvásári 2	0	50.78	100.00	0.00
	14	47.26	93.07	− 6.93
	28	34.64	68.21	−31.79
Arthur	0	44.50	100.00	0.00
	14	41.63	93.55	− 6.45
	28	37.64	84.58	−15.42
S.D. 5%		5.38		
1%		7.21		
0.1%		9.51		

weight of infected plants was found on the 14th day after inoculation, a decrease occurred by the 28th day. The damage caused by the infection was the most serious in the case of Kavkaz. The yield loss in Martonvásári 2 was less than in Kavkaz, but more than in Bezostaya 1. Arthur showed a strong defensive reaction to the attack of the pathogen. In spite of the fact that powdery mildew was not able to spread in this variety, a substantial decrease in the green weight of young plants was demonstrated.

The relationship between productivity and degree of infection under field conditions is shown with Kavkaz (Table 2). The difference in yield components between resistant and moderately susceptible plants is not significant, though it shows a decreasing tendency. The reduction of grain yield as a response to strong powdery mildew infection is connected with the lower level of the yield components. Taking the yield components of resistant plants as 100%, in the case of susceptible plants (infection over 40%) they are:

— grain weight/spike	80.0%
— grain number/spike	86.3%
— thousand-grain-weight	95.5%.

The plants were more severely affected by the stem rust than by the powdery mildew. When infected by stem rust even the moderately susceptible plants differed significantly from the resistant ones as regards their yield components. In susceptible plants the yield loss was

Table 2

Trend of yield components in the variety Kavkaz as a function of the intensity of powdery mildew and stem rust infection (1971/72)

Type of infection		n	Grain weight/spike (g)		Grain number/spike		Thousand-grain-weight (g)	
powdery mildew	stem rust		$\bar{x} \pm S_{\bar{x}}$	%	$\bar{x} \pm S_{\bar{x}}$	%	$\bar{x} \pm S_{\bar{x}}$	%
R	R	81	2.05 ± 0.09	100.0	44.49 ± 1.52	100.0	44.71 ± 0.77	100.0
R	MR	152	1.74 ± 0.06**	84.8	41.35 ± 1.22	92.9	41.12 ± 0.60***	91.9
R	S	86	1.42 ± 0.07***	69.2	35.56 ± 1.68***	79.9	39.13 ± 0.81***	87.5
MR	R	22	1.89 ± 0.21	92.2	38.77 ± 3.92	87.1	45.36 ± 1.33	101.4
MR	MR	30	1.89 ± 0.15	92.2	42.60 ± 2.76	97.7	43.15 ± 1.35	96.5
MR	S	13	1.23 ± 0.20***	60.0	29.45 ± 4.49***	66.2	41.94 ± 1.94	93.8
S	R	52	1.64 ± 0.08***	80.0	38.40 ± 1.69**	86.3	42.73 ± 0.82*	95.5
S	MR	76	1.61 ± 0.08***	78.5	37.70 ± 1.55**	84.7	41.48 ± 0.98**	92.8
S	S	66	1.13 ± 0.08***	55.1	30.16 ± 1.83***	67.8	36.24 ± 1.08***	81.5

* P = 5%
** P = 1%
*** P = 0.1%

still more substantial. The greatest damage was found in plants seriously affected by both powdery mildew and stem rust. Similar results were obtained with the other varieties and hybrid combinations.

The relationship between yield components and powdery mildew infection and between yield components and stem rust infection is negative and significant, which proves among other things that from populations heterogeneous for resistance a powdery mildew resistant material can be selected in challenging experiments. This is confirmed by the correlation coefficients (Table 3). This is all the more interesting because breeding for resistance can be regarded as a rational method of plant protection.

As mentioned above, Kavkaz was a heterogeneous population as regards resistance. In our experiments resistant plants made up 52—55%, moderately susceptible ones 11—14%, and susceptible plants 33—35% of the material. The yield loss was thus 5.2 to 7.7 %.

The extent of the damage depends on when and with what intensity the pathogen appears, and on the susceptibility of the varieties grown. A 5—8% loss may be evaluated from various points of view:

1 — according to some authors, it is no great loss and does not cause any particular shock to the national economy;

2 — the wheat area of Hungary is 1.3 million hectares. The national yield average is about 35 q/ha. In this case the loss is 2.3 to 3.6 million quintals. Reckoning with 240 kg seed-grain per hectare, this means a requirement of 3.1 million quintals. The damage caused by powdery mildew may thus be as much as the annual seed-grain requirement of the country. In our opinion this is a significant figure which makes protection against the pathogen necessary.

Table 3

Relationship between yield components and infection by powdery mildew and stem rust (1971/72)

Designation	r	a	b
Kavkaz			
Powdery mildew infection—			
grain weight/spike	—0.473***	2.09	—0.169
grain number/spike	—0.526***	47.18	—3.109
thousand-grain-weight	—0.411***	44.51	—1.483
Stem rust infection—			
grain weight/spike	—0.711***	2.38	—0.285
grain number/spike	—0.771***	50.09	—4.344
thousand-grain-weight	—0.824***	47.13	—2.423
Avrora			
Powdery mildew infection—			
grain weight/spike	—0.348***	1.79	—0.104
grain number/spike	—0.359***	41.34	—2.141
thousand-grain-weight	—0.289**	42.95	—0.745
Stem rust infection —			
grain weight/spike	—0.404***	2.08	—0.161
grain number/spike	—0.416***	47.54	—3.333
thousand-grain-weight	—0.227*	43.41	—0.641
F_1 (RPG 14/44× Bezostaya 1)× Bezostaya 1			
Powdery mildew infection—			
grain weight/spike	—0.652***	2.18	—0.012
grain number/spike	—0 602***	47.46	—0.211
thousand-grain-weight	—0.464***	47.65	—0.115

r = correlation coefficient
a = regression constant
b = regression coefficient

* P = 5%
** P = 1.0%
*** P = 0.1%

*

Prepared at the Agricultural Research Institute of the Hungarian Academy of Sciences, Martonvásár.

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THE INTRODUCTION OF AGARICUS MACROSPOROIDES INTO CULTIVATION

Fruiting bodies which served as the initial breeding material were collected on pasture land at Hortobágy on 12th May 1954. On 24th June 1974 this species, which had to be differentiated as a new species since its properties differed from those of known champignons, was found a second time at Hortobágy (BOHUS 1974). In the course of successive experiments, fruiting body formation was attained in the fifties, and the species was introduced into cultivation in 1970.

One of the research workers was Adél Uzonyi-Látkóczky who concentrated primarily on clarifying the conditions of spore germination (UZONYI-LÁTKÓCZKY 1965) and on elaborating a method similar to the cultivation of the two-spored champignon. Unfortunately her early death in 1970 put an end to these investigations.

In this paper the results of my own investigations are presented.

The place of Agaricus macrosporoides among the cultivated and wild mushrooms from an ecological point of view

It seems that at a population level the mushrooms of highly acidic forest soils grow under the most complicated conditions, and most of them are mycorrhizal such as, e.g. *Boletus edulis*, *B. aestivalis* and *B. pinicola*. In the case of these communities the complexity involves not only the close connection with woody plants but also the many-sided interactions between the species themselves. In the course of cenological examinations it was possible to form an idea of the crowdedness of these communities. The upper layers of such forest soils are thickly interwoven with mycelia. The mycelia of certain species grow through the mycelia of others; fruiting bodies appear within each other's colonies. These species assimilate an enormous number of influences; favourable, promoting and inhibitory factors act at the same time. The spores fall into this "totally occupied" space. Which of them will germinate and settle? Is there any possibility for a new individual to establish itself at all? It seems there must be, perhaps through the promoting effect of certain species in the population. This seems likely, because in distant stands of certain forest types the mushroom combinations are similar, or at least quite a high percentage of the species are identical. This could hardly be otherwise even if the site conditions are similar. In the course of interactions highly critical effects are realized, without which the survival of the species in question might not be ensured. In another field an answer has already been received to this question: under conditions that exclude bacteria *Agaricus bisporus* is usually unable to develop fruiting bodies.

Progressing from the complicated situation described above to those less complicated, the situation for the saprophytes growing in forests is somewhat simpler due to the absence of mycorrhizal connections, but it is still complicated by the interactions between the species. The situation is simpler in the case of *Agaricus bisporus*, which is also saprophytic and which usually lives on neutral or moderately alkaline manure, or manured soil in populations of bacteria or actinomycetes rather than with other mushroom species. *Agaricus bitorquis* lives under similar conditions, on neutral or alkaline soils with no other mushroom species in its environment.

Finally, of the cultivated species, in the case of *Volvariella volvacea* and *Stropharia rugoso-annulata*, which grow on fresh straw, and *Pleurotus ostreatus*, *Lentinus edodes*, etc., which live on fresh wood, there is hardly any competition to their settling even from bacteria and actinomycetes. It is not by chance that most species which have so far been successfully introduced into cultivation belong to these species.

Agaricus macrosporoides represents an intermediate stage in the outlined ecological order. It lives on moderately acidic soils on grasslands with no significant competition from other mushrooms. An opportunity was afforded to watch this area during a peak period of fungus production and it was concluded that the mycelial thalli of the different species were separated by a larger or smaller distance, or at most they adjoined.

Method

Pots: 800 ml glass vessels with Petri-dish covers and paper wadding air filters.

Culture media: normal cob-grist medium: 100 g cob-grist per pot, 10 g lucerne meal, 5 g soya meal, 1 g mineral salt mixture swollen with 375 ml hot water for half an hour, then poured into a glass vessel and sterilized at the desired temperature for 1 hour. After this the culture medium is taken out of the autoclave to cool down so that the air filter will not be moistened. The salt mixture used is a commercial mineral premix with the following salt content: secondary calcium phosphate, manganese sulphate, iron sulphate, zinc sulphate, copper sulphate, cobalt sulphate and potassium iodide.

Information about the composition of other culture media and a description of further techniques are given in the discussion of the individual experiments.

Investigations into the optimum composition of the culture media are not included in the publication.

Yield % = weight of fruiting bodies related to the dry matter weight of the culture medium. For example, if the weight of the fruiting bodies is 150 g and the dry matter weight of the culture medium is 100 g, then the yield percentage is 150%.

Effect of temperature

Mycelial growth and temperature. Agaricus macrosporoides does not seem to react to temperature; it shows an almost optimum growth between quite wide temperature limits (19—28°C).

Below 5°C the growth is very slow; below 10°C it is still protracted, hardly reaching 14% of the optimum rate of growth. By contrast, in 18 strains of the cultivated champignon growth below 10°C attains 25—75% of the optimum. The optimum temperature is 24—27°C, the maximum about 32°C; at this temperature growth could not generally be observed (Tables 1 and 2).

The rapid growth at relatively high temperatures — even at 28°C — is interesting. It may be due to the open grassy habitat of this species, where under the influence of the sunshine the upper layers of the soil warm up to a higher degree. The same observation was made earlier on several other open field species.

Table 3 shows the extent of mycelium growth as a function of temperature for 23 strains. The interval 18—20°C appears twice; in the second case the temperature was near 18°C for a a considerable length of time.

Table 1

Effect of temperature

Mycelium growth in Treschow's synthetic culture solution modified with 0.2% agar-agar; source of nitrogen: peptone. 50 ml culture solution in each 100 ml flask. Incubation for 20 days. Number of replications: 3*

Temperature °C	Dry matter weight of mycelium, mg
31 —32	5
28 —30	141
23 —24.5	164
19 —22.5	157
15 —19	92
13 —16	86
10 —13.5	55
8 —10.5	22
3.5— 5	not measurable (growth: 1 mm)

Table 2

Effect of temperature

Mycelium growth in Treschow's synthetic culture solution modified with 0.36% agar-agar; source of nitrogen: peptone. 50 ml culture solution in each 100 ml flask. Incubation for 20 days

Temperature °C	Number of replications	Dry matter weight of mycelium, mg
26—27	3	168
	8	173
24—25	3	163
	8	165

* Composition of Treschow's culture solution (1944) without the nitrogen source: 10 g glucose, 0.2 g KCl, 0.2 g $MgSO_4 \cdot 7\,H_2O$, 0.2 g $CaCl_2 \cdot 6\,H_2O$, 0.2 g KH_2PO_4, 0.72 g $Na_2HPO_4 \cdot 7\,H_2O$, 1 ml 1% $FeCl_3 \cdot 6\,H_2O$, 0.1 g malt extract, 50 μg aneurin dissolved in distilled water to 1000 ml (adjusted to pH 6.5 by means of N/1 NaOH).

Table 3

Mycelium growth in test tubes containing 3% malt extract-agar, in diffuse light. Number of replications: 1. Year of experiment: 1974

Strains*	7–19.II.	22.III.–3.IV.	22.IV.–4.V.	23.V.–4.VI.	27.VI.–9.VII.
	15–19°C	18–20°C	18–20°C	21–22°C	23–24°C
	Radial growth of mycelium in mm				
Sp. 1.	21	32	19	33	22
Sp. 2.	26	36	32	37	18
Sp. 3.		34	33	31	52
Sp. 4.	16	20	19	25	33
Sp. 5.	25	36	37	46	44
Sp. 7.	19	37	26	27	33
Sp. 8.	9	9	10	14	8
Sp. 9.	18	33	33	30	44
Sp. 10.	19	32	24	27	30
Sp. 11.	29	37	34	42	46
Sp. 12.	23	41	30	38	29
Sp. 13.	19	35	28	37	47
Sp. 14.	27	40	40	39	37
Sp. 15.	23	33	42	42	38
Sp. 16.	32	22	35	44	31
Sp. 17.	20		43	38	40
Sp. 18.	8	41	33	42	41
Sp. 19.	23	40	32	33	42
Sp. 21.	25	29	30	42	26
Sp. 22.	6	33	30	38	29
A.m. 14/3.	31	25	32	46	48
A.m. 14/3/1.	25		16	37	35
A.m. 20.	23	38	37	28	42

* Sp. = monospore, A.m. = multispore cultures. To attain a more uniform growth primordia were used for inoculation, except in culture Sp. 8, which lost its capacity to develop primordia (owing to this change its growth also became slower)

Fruiting body formation and temperature

In a number of experiments the role of temperature was found to be more complicated from the point of view of fruiting body formation. It could be demonstrated that fruiting body formation required lower temperatures than mycelium growth. This was indicated by the following data: 1) the weight of fruiting bodies produced at 23—24°C was only 40% of the weight of those developing at 19—22°C (Table 4); 2) in cultures of different age (one and a half to two months), where the mycelia had developed at a temperature of 24—28°C, the fruiting bodies appeared at once when the temperature was reduced permanently to 20—22°C; 3) at 16—

Table 4

Temperature and fruiting body weight. Grown on a normal cob-grist culture medium for 90 days

Temperature	Dry matter weight of the culture medium g	Fruiting body weight g	Fruiting body weight per 100 g dry matter weight of culture medium g
23.4—23.8°C	580	183	31
19—22°C	1080	915	84

20°C the fruiting bodies appeared earlier: 4) above 22°C *Agaricus macrosporoides* often does not produce fruiting bodies at all. In one of the experiments not a single fruiting body developed at 25°C in 108 days, in an other experiment similarly in 67 days, while at 20°C 14 fruiting bodies grew during the same time, some 80% of the usual total yield.

The results of many experiments demonstrate that cultures should be kept at 16—19(20)°C if fruiting bodies are to be obtained. Further, it has been shown that on certain "richer" culture media — e.g. those with cob-grist as basic material — there must be special temperature

Table 5

Change of temperature and fruiting body formation. Grown on a normal cob-grist culture medium. The 11 cultures were 40—50 days old at the beginning and 80—90 days old at the end of the observation

Date 1973	Temperature, °C	Number of developing fruiting bodies	Date 1973	Temperature °C	Number of developing fruiting bodies
Sept. 4	19.4		Sept. 23	19.2	2
5	19.4		24	19.2	
6	19.4		25	18.4	
7	19.6		26	18.2	
8	20.0		27	18.0	
9	20.2—19.4		28	17.6	5
10	19.6—18.0		29	17.6	1
11	19.6—18.0		30	17.6	
12	19.4		Oct. 1	17.4	
13	20.4				
14	20.2	7	2	17.2	
15	20.4	1	3	17.2	
16	20.0		4	17.2—18.2	
17	20.0		5	18.2	
18	19.2		6	18.2	3
19	19.2—17.8		7	18.4	7
20	19.4—17.2		8	18.6	3
21	19.4	3	9	18.6	3
22	19.4		10	18.2	

effects at a later stage of fruiting body induction, since although many fruiting body primordia are able to appear after the development of the mycelium more or less irrespective of the temperature, the regular development of primordia into fruiting bodies requires 16—18°C for at least 2—3 days. It was found that in cultures kept at temperatures higher than 18°C after the growth of the mycelium numerous primordia which appeared grew somewhat more, became tuber-like and deformed, new primordia appeared on them, then all of them gradually died. This process was repeated until one of the primordia nevertheless succeeded in developing into a fruiting body. This phenomenon does not occur if the cultures are placed at a temperature of 18°C or lower soon after the completion of the mycelium development. On "poorer"* culture media — e.g. those with straw as basic material — temperatures of 18°C or lower after the completion of the mycelium development are just as necessary for fruiting body formation as in the former case, except that the primordia do not develop into deformed tubers and do not die even if the temperature is higher.

Temperature fluctuations between 16° and 20°C have a favourable effect on fruiting body formation (Table 5).

Table 6

Temperature conditions at Hortobágy in June 1974

Date	Maximum °C	Minimum °C
June 8	17	10
9	19	8
10	22	14
11	15	13
12	17	11
13	12	10
14	12	10
15	12	8
16	17	8
17	23	8
18	25	13
19	25	14
20	27	14
21	22	13
22	25	10
23	24	17
24	25	17

* The terms "rich" and "poor" do not, in fact, refer to higher and lower nutrient contents, but rather to a stronger or weaker inclination to fruiting body formation, as induced by the composition of the culture medium. On certain cob-grist culture media (e.g. in the experiments on 25th November 1974, and 7th, 13th and 19th March 1975) the appearance of fruiting body primordia was so intensive that in spite of the fact that the temperature was lower than 18°C many primordia first grew prolifically and then died. A further effect of the unknown factor of the culture medium was the production of maximum in most of these experiments.

Table 5 is just one example of a number of similar observations. It shows that a special change of temperature induces fruiting body formation. Namely, when the temperature falls by one or two degrees, from 19—20°C to 17—18°C, or increases by one or two degrees from the latter level fruiting bodies start to develop sooner or later after the change in temperature.

An opposite example: in the fruiting body formation period the temperature was permanently 16.5—17°C over 24 days; although fruiting bodies were produced in some of the 14 cultures, in the others only fruiting body primordia appeared, some of which were dying. In these cultures in the absence of temperature fluctuations the primordia were not able to develop into fruiting bodies in spite of the favourable temperature.

This special heat requirement for fruiting body formation seems to agree with the results of the few field observations made so far, since mushrooms have been collected once in the first half of May, and once on 24th June, after a period of cool weather. The trend of temperature before the appearance of the fruiting bodies is shown in Table 6.

Effect of light

Mycelium growth and light. Light has no special effect on the growth of the mycelium. The interlacing of the culture medium is largely the same in the light and in the dark. One difference may be observed, however, when the mycelium develops in the light: the fruiting body primordia appear earlier. In one of the experiments, on a culture medium containing cob-grist as basic material, many fruiting body primordia developed in the light within 30 days, while in cultures kept in the dark no primordia were observed in the same period. Mycelium growth in the light may also result in the earlier appearance of the fruiting bodies, but — according to the results of experiments performed so far — does not influence the yield.

Fruiting body formation and light

Light is necessary during the period of fruiting body formation; the amount of light influences the shape of the mushroom. Without light the stipe — mainly at its lower part — will be thick, and the pileus small. For example, on 21st August 1972, in mushrooms growing in the dark the thickness of the stem was 3.5 cm and the pileus diameter 1 cm; on another occasion (25th October 1973) the same measurements were 4.5 and 1 cm, respectively. (Fig. 2a). The more the light the wider the pileus and the shorter the stipe. By varying the amount of light the shape of the mushroom can be more or less modified as required. With a specific amount of light mushrooms with longer stems and moderately broad caps can be produced which are easy, to pack (Figs. 2b, 3). Mushrooms growing in full light in nature have broad caps up to 25 cm in diameter, while their stems are relatively short (8—9 cm) and thick (4 cm) (Fig. 1). Fruiting bodies in the course of development may stop growing if the light is removed.

Light is one of the factors that determine the vertical position of the fruiting body. Fruiting bodies turn more or less towards the light. Turning from a horizontal to a vertical position has also been observed. A 1.5 cm long fruiting body growing horizontally on the surface of the culture medium in a thermostat without illumination on 11th February 1972 turned into a vertical position and attained a weight of 85 g within 4 days after a 15 W neon tube was switched on at a distance of 40 cm. It was found that the bending of the stipe had no part in this change of position, since the stipe was only slightly curved; that part of the stipe base which was in contact with the culture medium grew in such a way as to gradually raise the stipe into a vertical position.

The intensity of illumination also plays a role among the factors determining the site of appearance of the fruiting bodies. If transparent culture vessels are used and if the intensity

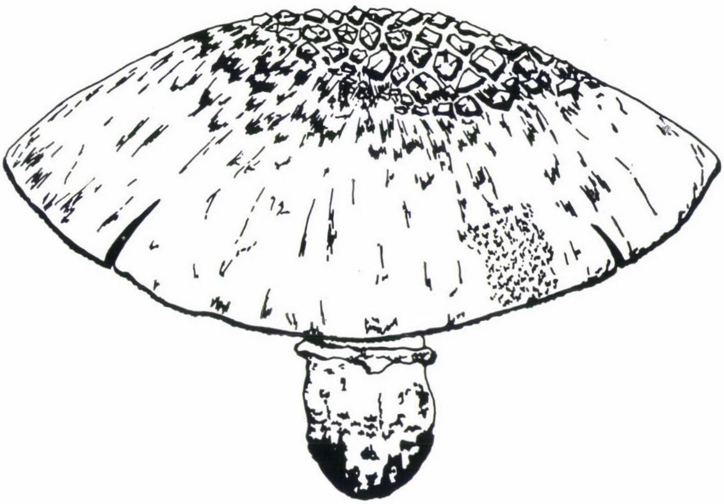
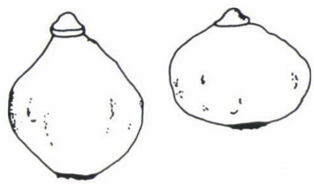
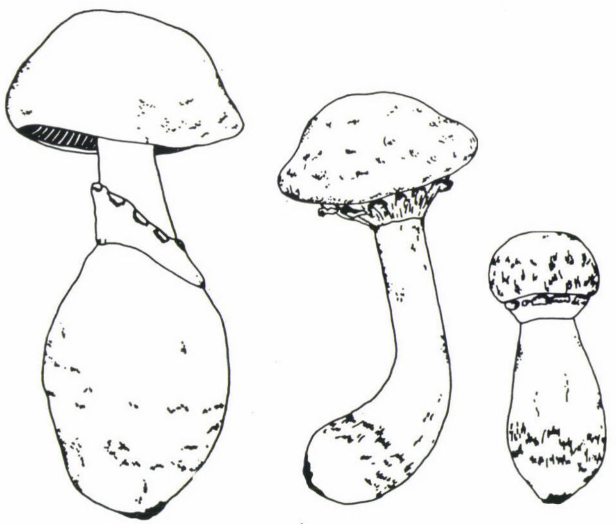


Fig. 1. Agaricus macrosporoides Bohus. Fruiting body developed in narural light. 2/5 size, Hortobágy N. P.: neighbourhood of Nagyiván, 24th June 1974. coll. M. Babos



a,



b,

Fig. 2a. Fruiting bodies growing without light. 2/5 size.
b. Fruiting bodies growing in artificial light. 2/5 size.

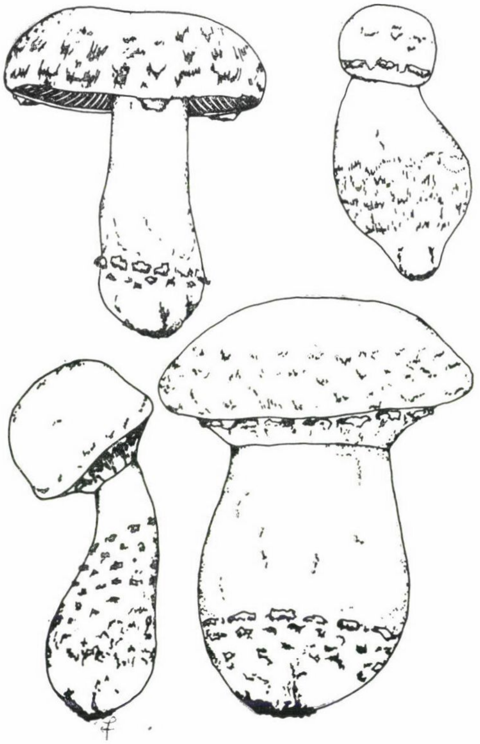


Fig. 3. Fruiting bodies growing in artificial light. 2/5 size

of light is rather high (around 400 lux), the fruiting bodies appear not only on the open upper horizontal surface, but also — though to a smaller extent — on the closed lateral walls. If the intensity of light is decreased to 60 lux, all of the 134 fruiting bodies, grown during one observation period, appeared on the open horizontal surface.

The water content of the culture medium, the role of air humidity, and transpiration

During mycelium development. The water demand of this species did not seem to differ from that of *Agaricus bisporus.* When grown under sterile conditions the mycelium interlaces the culture medium so densely that it becomes impermeable by water; water cannot, therefore, be added afterwards. Thus, the total amount of water required until yield production should be added when the culture medium is composed. The amount of water necessary in the case of sterile cultivation, maintaining sterile conditions during the full development of the mycelium, is 75—82% of the culture medium — 75% with cob-grist and 82% with straw + peat as basic material.

Air humidity should be about 90%, in order to reduce the water loss in the upper layers of the culture medium to a minimum.

During fruiting body formation. The water content of the culture medium and the extent of air humidity were found to have an influence on the place where the fruiting bodies appear and on the direction in which they grow. With a relative humidity of around 100%, 95—100%

of the fruiting bodies are vertical. If less than the usual amount of water was added to the culture medium, and harvesting took place at a humidity lower than 90%, the proportion of non-vertical fruiting bodies and of those developing in deeper layers of the culture medium was as high as 70%. EGER (1964) found that *in vitro* the fruiting bodies of *Macrolepiota rhacodes* showed no geotropic reaction. He explained this by the inability of the artificial growing conditions to satisfy the requirements of the mushroom.

As to the role of air humidity further questions arose. 1) If the fruiting bodies begin growing under humid conditions will they continue to grow at a lower humidity, and if so, will they be of regular shape? This question is related to the assumption — made for the time being on the basis of very few data — that *Agaricus macrosporoides* is a steppe species. 2) How high is the transpiration of the fruiting bodies? Fruiting bodies which started to grow at a humidity of about 100% were found to continue growing until they were fully developed even when the air humidity fell to 50—60%; the drier air had no harmful effect on them. Even very dry air with a humidity of 35% had no unfavourable influence on the development of the fruiting bodies. Mushrooms growing under such conditions, however, became of harder texture, that is relatively heavier than those developing in humid air.

The data in Table 7 give information about the degree of transpiration. Thus, if *Agaricus macrosporoides* is compared to the species examined by MOSER (1965), it is found to belong to the group of species with relatively low transpiration. Fruiting bodies developing in a humid environment show increased transpiration compared to those growing in "dry" air. The amount of water evaporated and replaced is quite considerable even if the transpiration of the fruiting bodies is relatively low.

In the case of a fruiting body weighing 95 g, at a relative humidity of 35%, the amount of water evaporated was 33 g, one-third of the weight of the fruiting body. This observation, together with the fact that this fungus species is able to produce fruiting bodies even under such arid conditions implies that the transport of water is quite rapid, though it is difficult to imagine how it takes place.

Table 7

Transpiration of fruiting bodies in mg per g fresh weight and per hour

Vapour content percentage during growth of fruiting bodies	Fresh weight at the beginning of transpiration, g	Transpiration in mg/g fresh weight in the 1st hour	2nd hour	3rd hour	4th hour	Note
		Vapour content percentage 35, Temperature: 16–18 °C				
35	94.54	15.6	15.3	15.4	14.4	Fruiting body squat
35	77.0	22.0	22.5			
100	51.8	21.0	19.2	21.0	19.8	
100	38.1	28.5	27.2	28.5		
100	11.0	38.7	40.3	37.1		Fruiting body small
		Vapour content percentage 40, Temperature: 25–25.5°C				
90—100	30.6	41.0	43.1	43.3		

Air requirement

There is no special air requirement during mycelium development. True, it first covers the well-ventilated surface and only later penetrates into the deeper layers, but it does so at a good rate even if the culture medium is relatively compact. This shows that in glass or other airtight pots the absence of air and the higher carbon dioxide content in the deeper layers does not exert any harmful effect on the mycelium.

Fruiting bodies grow on the surface of the substrate exposed to the atmosphere. During fruiting body formation carbon dioxide-induced inhibition appears in *Agaricus bisporus* as soon as the concentration exceeds a certain low value. With *Agaricus macrosporoides* this inhibition cannot be observed. Even in glass culture pots ventilated insufficiently through a cotton air filter regular fruiting bodies develop. Thus, this mushroom does not require the intensive air exchange used for *Agaricus bisporus*. Investigations made so far have shown that in a space ten times the volume of the culture medium ventilation twice a day is sufficient. Without this, however, deformed fruiting bodies develop. If the cultures producing deformed fruiting bodies were transferred to better ventilated conditions the fruiting bodies subsequently developed were of regular shape.

The effect of the hydrogen ion concentration in the culture medium

The question arose, what pH values were preferred or tolerated by *Agaricus macrosporoides*. Since there was no opportunity to make field studies on this subject, we examined the regulatory capacity of the fruiting body, that is, its influence on the acidity of its immediate environment (method: Bohus 1973).

The results of the examination suggest that this species is of subacidophilous character: the regulation produces a pH- value slightly over 5.5 (Table 8).

Table 8

Regulation of mycelium and fruiting bodies in non-buffered solution series

Mycelium				Fruiting bodies			
2.IV.69		4.VI.69		4.VI.69		23.X.69	
pH values							
a	b	a	b	a	b	a	b
3.3	4.5	3.0	4.1	3.0	4.5	3.3	4.7
4.2	5.5	4.0	5.4	4.0	5.7	4.2	5.6
5.1	5.6	5.5	5.8	4.8	5.9	5.1	5.7
6.1	5.9	6.1	5.9	6.1	6.0	5.9	5.8
7.0	6.0	6.8	5.9	6.9	6.1	7.2	6.1
8.1	6.3	6.9	6.1			7.5	6.3

a = solutions adjusted to the indicated pH- value but not buffered
b = pH- values changed by the mycelium colonies or fruiting bodies after 1 hour of incubation at 24°C

Mycelium growth and the hydrogen ion concentration of the medium

As was mentioned above (Bohus 1973), it is difficult to determine the pH requirement of the mycelium by means of *in vitro* experiments, because the results depend on the composition of the culture media. For example, when the carbon source is saccharose a pH of 6.5 is unfavourable while pH 4.0 is favourable. On the other hand, when the carbon source is glucose both degrees of acidity are favourable (Table 9).

In the case of glucose more favourable conditions can be created by buffering to pH 5 (Table 10).

In order to obtain further information a buffer series was used with glucose as the carbon source (Table 11).

It can be established that with Treschow solution (Treschow 1944) the optimum pH-value is between 5 and 6. Furthermore, the mycelium growth is fairly good even under highly acidic conditions (pH 4). This was demonstrated by experiments aimed at studying the utilization of ammonium salts. During the assimilation of ammonium salts the pH- value of the

Table 9

Effect of pH on saccharose and glucose utilization in Treschow's synthetic culture solution, at 22.5—24.5°C. 50 ml culture solution in each 100 ml flask. Incubation: 20 days. Number of replications: 4—6

Carbon sources in a 1% quantity	Nitrogen sources in a 0.1% quantity	Initial pH	Final pH		Dry matter weight of mycelium, mg
D-glucose	peptone		6.8	6.9	93
Saccharose		6.5	7.0	7.1	12
	glycocol		6.8	7.1	7
Buffered to pH 4 (1 part culture solution + 1 part phosphate buffer solution)					
D-glucose	peptone		3.8	3.8	70
Saccharose		4.0	3.8	4.3	75
	glycocol		4.1	4.5	50

Table 10

Effect of pH on glucose utilization in Treschow's synthetic culture solution at 23.9—24.7°C. Nitrogen source: peptone. 50 ml culture solution in each 100 ml flask. Incubation: 20 days. Number of replications: 4

Carbon source	Initial pH	Final pH		Dry matter weight of mycelium, mg
0.5% D-glucose	6.5	5.7	5.9	102
	5.0 buffered (1 part phosphate buffer solution + 1 part culture solution)	4.9	5.0	162

Table 11

Effect of pH on mycelium growth in Treschow's synthetic culture solution at 23.8—24.2°C. Nitrogen source: peptone. 50 ml culture solution in each 100 ml flask. Incubation: 30 days. Number of replications: 4

pH- values adjusted with phosphate buffer (3 parts buffer solution + 2 parts culture solution)	pH- 3	pH 4	pH 5	pH 6	pH 7	pH 8
Dry matter weight of mycelium, mg	0	135	144	201	86	0

nutrient solution fell to pH 3—4 within a few days, but the mycelium production of this species was still fairly good compared to many other mushroom species, because it tolerated the higher acidity of the medium relatively well.

Fruiting body formation and the pH of the culture medium

This question can best be examined under sterile growing conditions and on a complex culture medium. Fruiting body formation can be attained with culture media above pH 6, sometimes even at a pH- value of 6.7. If a satisfactory yield is to be obtained the hydrogen ion concentration of the culture medium should be below pH 6. We obtained a good yield even on a culture medium with an initial pH- value of 4.5.

Mycelium growth does not substantially change the acidity of the culture medium, but, in an interesting manner, the fruiting body formation has a considerable effect on it (Table 12).

Other experiments also showed that the final pH- value was mostly between 4.2 and 4.7. Within one particular experiment there was no correlation between the amount of yield and the final pH- value (Table 13).

Table 12

Changes in the acidity of the culture medium in the course of fruiting body formation

pH values	
After mycelium growth	After harvesting
5.8	4.9
5.5	4.5
4.9	4.2 4.5
5.1 5.2	4.3

Table 13

Yield and final pH
Growing on normal cob-grist culture medium for 90 days

Yield %	Final pH
101	4.5
94	4.5
79	4.5

Sterilization temperature of the culture medium and the speed of mycelium development

The best way to study this question was by inoculating the centre of the surface of the culture medium and measuring the diameter of the mycelium colony.

The optimum sterilization temperature was found to be 104—115—(120)°C in the case of cob-grist, and 120°C with wheat or rye straw as the basic material. It is at these temperatures that the basic material is best broken down for the mycelium (Table 14). The 100°C is also suitable in the case of cob-grist.

Table 14

Temperature of sterilization and extent of mycelium growth

Date of inoculation	Basic material for cultivation	Strain	Sterilization temperature °C	Diameter of surface thallus and depth of penetration into culture medium (figure after stroke) after 18 days' incubation at about 24°C, cm
7.I.74.	cob-grist	14/3	135°	3
12.X.74.		14/74	115°	9/2
25.X.74.				9/2
24.II.75.				9
7.III.75.				9/4
19.III.75.				9/3
8.IV.75.				9/5
25.X.74.		14/3		9/1
31.X.74.				9/2
25.XI.74.				9/3
6.XII.74.				9/3
13.III.75.				9/3
31.X.74.		14/4		9/3
22.I.74.		14/3	111°	9
23.I.74.				9/4
25.I.74.				9/3
31.I.74.				9/3
7.III.74.				9/2
29.III.74.				9/4
9.IV.74.				9
19.IV.74.				9/2
3.V.74.				9/2
23.V.74.				9/3
30.VII.74.				9/3
8.VIII.74.				9/2
8.VIII.74.		14/74		9/4
10.VII.74.		14/4		7
27.VII.74.				8
30.VII.74.		Sp. 14		9/I
27.VII.74.		Sp. 16		8
1.III.74.		Am. 20		9/2
14.XI.70.		14/3	104°	9
29.I.72.				9/3
11.XII.72.				8/2
10.I.72.		Sp. 3		9/2
10.II.72.		Sp. 2 + Sp. 3		9/1
8.I.75.	cob-grist + rice husks	14/3	111°	9/2
19.I.74.				9/4
29.III.74.	cob-grist + rye straw		120°	6
21.XI.74.				9/4
22.I.75.				9/3
14.II.74.	† rye straw			9
21.XI.74.				9/5
27.XI.74.				9/4
18.XII.74.				9/4
27.III.75.	wheat straw	14/74		9/4

Mycelium development

After the inoculation the development of the mycelium gradually accelerates. The growth at a temperature above 24°C should last not only until the mycelium has taken possession of a large proportion of the culture medium but also until a nutrient reserve has been accumulated for fruiting body formation. This period must not, however, be longer than necessary, otherwise fruiting body formation will naturally be delayed. Under the experimental conditions used the length of the mycelium growth period depended on the method of inoculation (Table 15).

The delay of fruiting body formation in the case of protracted mycelium growth is shown in Table 16.

Table 15

Changes in period of mycelium growth depending on inoculation method

Method of inoculation	Period of growth in days
At centre of surface	25—32
At many points of surface	18—20
Spawn mixed with culture medium	9—13

Table 16

Period of mycelium growth and amount of yield in the 60 days after inoculation

Method of inoculation	Period of growth in days	Number of experiments	Number of cultures	Average yield, %
At centre of surface	25—32	23	54	41
	37—52	10	24	10
Mixing	9—13	12	19	107

Appearance of fruiting bodies

After 10—30 days of mycelium development the cultures are placed under the temperature, light and humidity conditions outlined above, and soon afterwards the period of production begins; some of the fruiting body primordia start growing and develop into fruiting bodies. During the first ten days of the "production" period, mushrooms were very seldom obtained: in the experiments performed so far only in 4% of the cultures; during the second ten days, they appeared at a faster rate: in 33% of the cultures, and during the third ten days in 37%. The time when the first fruiting bodies appear is influenced by the basic material and the method of inoculation: on cob-grist inoculated in the centre of the surface it is 22 days, on straw basic material 32 days, and if the spawn is mixed with the culture medium it is 26 days on average (Table 17). In the parallel cultures in the experiments the fruiting bodies often do not appear at the same time, although the conditions are practically identical. The appearance of the fruiting bodies during the production period is influenced by the method of spawning, the strain used, the composition of the culture medium and other factors. Relevant examples are shown in Table 18.

Table 17

Harvesting time of the first fruiting bodies

Date of inoculation	Number of days from the beginning of production in			Date of inoculation	Number of days from the beginning of production in		
	1st	2nd	3rd		1st	2nd	3rd
	parallel culture				parallel culture		
Basic material: cob-grist; inoculation in the centre of the surface							
6.III.70.	13			26.VI.73.	14	14	15
3.IV.70.	10	25	31	13.VII.73.	27	29	32
11.V.70.	22	22	38	21.VII.73.	12	13	15
10.VIII.70.	3	17		11.X.73.	20	27	
22.VIII.70.	27			24.X.73.	13	21	21
17.IX.70.	6	16	37	17.I.74.	14	28	
14.XI.70.	16	18	18	22.I.74.	16	38	
4.I.71.	18	21	31	23.I.74.	15	36	
16.II.71.	18	31		25.I.74.	23	38	
24.III.71.	26	28	30	31.I.74.	24	27	35
27.VII.71.	25			1.III.74.	22		
2.VIII.71.	13			9.IV.74.	35	36	36
17.VIII.71.	28	31	33	23.V.74.	23	26	32
20.IX.71.	17			14.VI.74.	4	7	
4.II.72.	15	16		22.VII.74.	24	26	
10.II.72.	20			27.VII.74.	13	26	
11.II.72.	15	17	22	30.VII.74.	16	18	20
18.III.72.	30			8.VIII.74.	10	17	32
20.III.72.	16	16	17	12.X.74.	14	15	17
25.III.72.	28	37		25.X.74.	14	24	35
31.III.72.	21	22		25.XI.74.	13	14	28
26.IV.72.	33	37		15.I.75.	37		
12.XII.72.	27	27	31	12.II.75.	22	24	
18.XII.72.	14	18	26	24.II.75.	21	21	
22.III.73.	18			7.III.75.	21	22	
7.IV.73.	15	17		13.III.75.	34	34	
9.V.73.	15	15	15	19.III.75.	19	22	
31.V.73.	17	31	34	8.IV.75.	17	20	
4.VI.73.	34			19.XI.75.	18	18	
Basic material: straw; inoculation in the centre of the surface							
14.II.74.	19	22		15.I.75.	38		
21.XI.74.	21	35		22.I.75.	56	58	
21.XI.74.	40	42		21.II.75.	33		
27.XI.74.	8			27.III.75.	24	31	32
18.XII.74.	31	31		8.IV.75.	28		
Basic material: straw; spawn mixed with the culture medium							
7.IV.75.	19			21.VII.75.	29	33	
17.IV.75.	16			5.VIII.75.	26	26	
8.V.75.	21	22	27	13.IX.75.	21		
15.V.75.	25			5.X.75.	28	29	
24.V.75.	16	22		4.XI.75.	24		
30.V.75.	24	27	38	27.XI.75.	22	26	
20.VI.75.	27	28	36	9.XII.75.	21	25	
10.VII.75.	37	49					

Table 18

Appearance of fruiting bodies during the production period.
Source of nitrogen: 5% soya meal + 10% lucerne meal. Any difference indicated

Date of inoculation	Sterilization temperature in °C and number of replications		Data on the composition of the culture medium and on the inocula	Yield % number of days from inoculation 55	60	65	70	90

Basic material: cob-grist. Inoculation in the centre of the surface.
Inocula: in general wheat grain spawn inoculated from a malt agar culture

14/3

Date of inoculation	Temp.	Repl.	Data	55	60	65	70	90
14.XI.70.	105°	3	Inocula: wheat grain spawn inoculated from wheat grain spawn. Source of nitrogen: 10% soya meal	0	5	33	44	99
			Source of nitrogen: 10% soya meal	0	62	62	91	126
18.XII.72.	104°	2		23	54	74	74	110
31.V.73.	104°	3		19	34	51	51	90
13.VII.73.	111°	4	Source of nitrogen: 5% soya meal + 10% malt germ	0	0	18	74	112
21.VII.73.	111°	2		63	63	95	95	126
31.I.74.	111°	4		35	40	51	75	105
14.VI.74.	108°	2		45	45	54	54	96
25.X.74.	115°	2		19	24	24	56	94
25.XI.74.	115°	3		43	60	63	63	89
13.III.75.	115°	2		0	99	99	99	156

14/4

Date of inoculation	Temp.	Repl.	Data	55	60	65	70	90
10.VII.74.	115°	2	With 2% Futor	0	50	58	58	117
27.VII.74.	111°	2	With 2% Futor	0	0	49	84	94
6.XII.74.	115°	2	With 15 volume % perlite	0	0	0	41	123

14/74

Date of inoculation	Temp.	Repl.	Data	55	60	65	70	90
8.VIII.74.	111°	1	With 1% calcium carbonate	79	79	79	79	110
12.X.74.	115°	2	With 2% Futor	56	73	80	105	117
25.X.74.	115°	2	With 2% Futor	40	54	54	71	105
24.II.75.	115°	2		56	70	85	91	111
7.III.75.	115°	2	With perlite String spawn	68	68	108	108	136
19.III.75.	115°	2	Acidic peat added String spawn	80	80	102	113	151
8.IV.75.	115°	2	With less mineral salt Acidic peat added String spawn	59	79	79	105	116

A.m. 16

Date of inoculation	Temp.	Repl.	Data	55	60	65	70	90
3.V.74.	111°	2	With 3% calcium carbonate	13	38	38	38	85
23.V.74.	111°	3	With 3% calcium carbonate	18	40	40	73	84

A.m. 20

Date of inoculation	Temp.	Repl.	Data	55	60	65	70	90
9.V.73.	104°	4	Source of nitrogen: 5% soya meal + 10% malt germ	48	48	70	70	95

Amount of yield

The amount of yield varies with the composition of the culture medium, the conditions outlined above and the spawning method. Table 19 gives information about the maximum yields (over 125%) obtained in the course of the experiments.

The length of the production period is approximately 60 days.

The yield results of the examined strains show certain differences (Table 20).

Table 19

Yield maxima

Source of nitrogen: 5% soya meal + 10% lucerne meal. Any difference indicated

Date of inoculation	Number of replications	Data on the composition of the culture medium	Number of days from inoculation	Yield %
On straw as basic material, with acidic peat. Spawn mixed with culture medium. Inoculum: "active" cob-grist or straw spawn				
7.IV.75.	1		61	191
24.V.75.	1		75	168
17.IV.75.	1		60	161
21.VII.75.	2		83	149
15.V.75.	1		82	146
10.VII.75.	2		72	145
13.IX.75.	1		77	141
30.V.75.	1		70	138
5.VIII.75.	2		90	138
20.VI.75.	2		64	129
8.V.75.	2		67	128
On cob-grist as basic material. Inoculation in the centre of the surface. Inoculum: wheat grain spawn inoculated from a malt agar culture. Any difference indicated				
13.III.75.	2	Inocula: "active" cob-grist spawn. Culture medium previously cooked	85	157
19.III.73.	2	With acidic peat added. String spawn	83	151
15.II.75.	1		85	136
7.III.75.	2	With perlite added. String spawn	84	136
14.XI.70.	3		90	126
21.VII.73.	2	Source of nitrogen: 5% soya meal + 10% dried malt germ	90	126

Table 20

Yield results of some strains. Basic material: cob-grist or straw. Source of nitrogen: soya meal or soya meal + lucerne meal. Sterilization at 104—120°C. Mycelium growth + fruiting body formation: maximum 90 days

Strains	Number of replications	Percentage yield averages
14/3	63	101
14/74	15	128
Sp. 20	8	91

Effect of mixing spawn with the culture medium on the yield

If the culture medium is evenly mixed with the spawn not only will the production period be shorter, but the yield will also be strikingly higher than when other methods of inoculation are used (Table 21; control: Table 22). This result was largely due to the fact that the

Table 21

*Yield after mixing spawn with culture medium**
(Related to the dry matter weight of the culture medium without peat)

Date of inoculation	Spawn	Storage of inoculation material at 24°C Number of days	Strain	Mycelium growth + fruiting body formation Total number of days	Yield, %
8.V.75.	Straw spawn	—	14/3	53	115
				81	150
15.V.75.		—		53	110
				82	146
24.V.75.		7		51	128
				75	168
				88	190
30.V.75.	Cob-grist spawn	14		70	138
				82	155
20.VI.75.		5		64	129
				82	155
10.VII.75.		25		60	138
				82	183
21.VII.75.		35		67	130
				83	149
5.VIII.75.		5		68	117
				90	138
13.IX.75.		45		60	119
				77	141
7.IV.75.		14	14/74	29	100
				61	191
17.IV.75.		24		51	161
				71	181
7.II.76.		—		52	117
				85	148
		Average			
	Straw spawn		14/3	80	150
	Cob-grist spawn			65	125
				80	150
			14/74	60	136
				85	173

* Culture medium: 25.2% chopped wheat straw, 25.2% wheat straw meal, 5% lucerne meal, 2.5% soya meal, 1.4% dipotassium hydrophosphate, 0.5% mineral salt mixture, 30% acidic peat, 7—10% inocula, 375% hot water. Water absorption for half an hour. Sterilization at 120°C. With a single or no replication

spawn was suitably moist and active, so that the mycelium maintained its growth vigour and metabolic capacity and continued its development after inoculation virtually without a break. Five days later the penetration was often almost complete.

The spawn was mixed with the culture medium without the use of gas burners or bactericide lamps in an atmosphere made poor in germs by means of Junker tubes. Only one of the 64 cultures became slightly infected, but the mycelium of the champignon soon overgrew and suppressed the mould spots. Even in this case the infection originated from the spawn.

Yield waves

It was found that in most cultures the fruiting bodies were produced in two waves within 90 days of the inoculation. In the 50 cultures of the 1974 experiments (basic material: cob-grist) the situation was the following:

in 6% there was one wave of yield,
in 70% two waves, and
in 24% three waves of yield.

In the case of strain 14/3 the second wave followed 8—28 days after the first one, namely:

in 6% 8—10 days later
in 27% 11—15 days later
in 33% 16—20 days later
in 21% 21—25 days later
in 12% 26—28 days later

The third wave followed about 15 days after the second.

Characteristics of the fruiting bodies

Cap: 17—25 cm in diameter; initially hemispherical then flattening; whitish, finally whitish-ochre; scaly, towards the centre of the pileus the scales become larger; cracking may be areolate in the centre and radial elsewhere. (The scales and cracks are caused primarily by the drying effect of sunshine and air currents.) When touched it becomes more or less yellow.
Lamellae: width up to 12 mm; from an initial pale colour they finally turn blackish-brown; the edges are sterile.
Stipe: 8—9 cm long, 3.5—4.5 cm thick; more or less clavate; below the ring floccose-squamulose; white.
Ring: hanging; on the lower side dentate.
Flesh: white; in the stipe it may slowly become flesh-coloured or rusty-flesh-coloured.
Spores: ovoid, $8-9.5 \times 5-6$ μm.
Marginal cells: mostly clavate, $11-22 \times 3.5-13$ μm.

Under cultivation

(only the differing features)

Cap: diameter up to 12 cm; floccose-squamulose; white, when young it may be yellowish.
Lamellae: from a pale colour they often become rose-coloured
Stipe: up to 22 cm long; squamose-squamulose only at the base.

Flesh: does not usually change colour; Schäffer reaction positive or negative. Drymatter weight about 12%.

Smell: faint, anise-like.

The size of the fruiting bodies varies according to the growing conditions (Figs 2, 3). If the factors involved in fruiting body formation are present, a large number of light weight fruiting bodies are produced simultaneously. If the conditions are not favourable for fruiting body formation (e.g. the ventilation is insufficient) one of the primordia will finally begin to grow, but with difficulty. This fruiting body will, however, be large. In the course of the experiments the weights of the fruiting bodies ranged from 10 to 100 g.

The taste of the mushroom

About thirty people have prepared various dishes from a sufficient quantity of mushrooms, and it has been established that *Agaricus macrosporoides* is one of the tastiest mushrooms. According to the author and others, it can compare with the *Boletus* species. It takes only a few minutes' cooking to soften.

Basic materials for cultivation

Of the agricultural refuse, corn-cobs, wheat straw, rye straw and rice husk were examined. The results of some of the experiments are contained in Table 22.

Cob-grist ground to a size of till 5 mm is highly suitable as basic material. The yield is 100—120% on average, depending on the additives used. As mentioned before, the intensive development of primordia on special cob-grist culture media makes it necessary to decrease the temperature in order to prevent the appearance of overgrown, unviable primordia.

When straw was used as basic material this latter phenomenon was less important since the development of primordia was less vigorous. Both with wheat and rye straw the yield was lower. If, however, straw or cob-grist spawn is evenly mixed with the culture medium an even larger yield may be obtained than with cob-grist as basic material. Here, the virulence of the spawn is also of importance. This question will be discussed more fully later.

Rice husks are less suitable as basic material giving lower yields even when mixed with corn-cobs. On the other hand, they may be useful when the basic material has a delaying effect on the mycelium growth, because the delay can be compensated by the accelerating effect of the rice husks.

The amount of organic nitrogen source and the yield

It was found that either 10% soya-meal, 5% soya-meal + 10% lucerne-meal, 5% soya-meal + 10% dried malt germ or 15% malt germ were equally suitable, but with a smaller amount of nitrogen source the yield was lower (Table 23).

Ammonium salts as nitrogen sources and the yield

It is noteworthy that ammonium salts may be used as the only source of nitrogen and ensure a medium amount of yield; if, however, the spawn is mixed with the culture medium (see page 306) a good yield is obtained (Table 24). If the ammonium salt is added with a small quantity (5%) of organic nitrogen, it seems that both nitrogen sources will be used since the yield will be higher than when 5% organic nitrogen is applied by itself. The yield does not change when the amount of organic nitrogen is increased (Table 24).

Table 22

Yield according to the basic material of the culture medium. Strain: A.m. 14/3

Composition of culture medium	Sterilization temperature	Date of inoculation	Method of inoculation	Number of replications	Production period in days	Yield, %
Basic material: cob-grist						
120 g cob-grist 12 g soya meal 0.6 g mineral salt 350 ml water	105°	14.XI.70.	Wheat grain spawn at the centre of the surface	3	90	126
120 g cob-grist 12 g soya meal 1.2 g mineral salt 375 ml water	104°	12.XII.72.		4	105	107
120 g cob-grist 6 g soya meal 12 g lucerne meal 1.2 g mineral salt 375 ml water		18.XII.72.		2	90	110
100 g cob-grist 5 g soya meal 10 g malt germ 1 g mineral salt 390 ml water	111°	21.VII.73.		4	80	106
120 g cob-grist 6 g soya meal 12 g lucerne meal 1.2 g mineral salt 375 ml water		11.X.73.		3	90	126
100 g cob-grist 5 g soya meal 10 g lucerne meal 1 g mineral salt 400 ml water		23.I.74. 25.I.74.		2 2	90 90	103 112
100 g cob-grist 5 g soya meal 10 g lucerne meal 1 g mineral salt 2 g Futor 400 ml water		31.I.74.		2	70	116
110 g cob-grist 5.5 g soya meal 11 g malt germ 1.1 g mineral salt 2.2 g Futor 440 ml water	108°	14.VI.74.		1	85	107
100 g cob-grist 5 g soya meal 10 g lucerne meal 1 g mineral salt 400 ml water	115°	13.III.75	Cob-grist spawn at the centre of the surface	2	85	157

(Table 22 continued)

Composition of culture medium	Sterilization temperature	Date of inoculation	Method of inoculation	Number of replications	Production period in days	Yield, %
Basic material: wheat straw + cob-grist						
40 g wheat straw 20 g cob-grist 2 g soya meal 4 g lucerne meal 0.4 g mineral salt 340 ml water	120°	21.XI.74.	Wheat grain spawn at the centre of the surface	2	105	106
Basic material: rye straw + cob-grist						
40 g rye straw 20 g cob-grist 2 g soya meal 4 g lucerne meal 0.4 g mineral salt 340 ml water	120°	22.I.75.	Wheat grain spawn at the centre of the surface	2	90	85
Basic material: rye straw						
80 g rye straw 4 g soya meal 8 g lucerne meal 0.8 g mineral salt 320 ml water		14.II.74.		2	95	103
40 g rye straw 2 g soya meal 4 g lucerne meal 0.4 g mineral salt 340 ml acidified water	120°	18.XII.74.	Wheat grain spawn at the centre of the surface	2	90	95
50 g rye straw 2.5 g soya meal 5 g lucerne meal 0.5 g mineral salt 420 ml acidified water		21.II.75.	**	1	90	100
Basic material: wheat straw						
40 g wheat straw 2 g soya meal 4 g lucerne meal 0.4 g mineral salt 340 ml acidified water		21.XI.74.	Wheat grain spawn at the centre of the surface	2	100	102
20 g wheat straw 20 g straw meal 2 g soya meal 4 g lucerne meal 0.4 g mineral salt 1 g K_2HPO_4 12 g dry acidic peat*** 150 ml water		8.V.75. 15.V.75.	Straw spawn mixed with the culture medium	3	65	125
	120°	24.V.75.		1	50	128

(Table 22 continued)

Composition of culture medium	Steriliz-ation temper-ature	Date of inoculation	Method of inoculation	Number of re-plica-tions	Produc-tion period in days	Yield, %
28 g wheat straw 12 g straw meal 2 g soya meal 4 g lucerne meal 0.4 g mineral salt 1 g K_2HPO_4 12 g dry acidic peat*** 150 ml water		30.V.75. 20.VI.75. 11.VII.75. 5.VIII.75. 13.IX.75.	Cob-grist spawn mixed with the culture medium	9	70	129
		21.VII.75.		2	70	130
Basic material: rice husks + cob-grist						
50 g cob-grist 50 g rice husks 5 g soya meal 10 g malt germ 1 g mineral salt 390 ml water	113°	24.X.73.	Wheat grain spawn at the centre of the surface	4	90	82
48 g cob-grist 32 g rice husks 2.4 g $(NH_4)_2SO_4$ 4.8 g $CaCO_3$ 0.8 g mineral salt 290 ml water	111°	19.II.74.		2	90	79

* Time of mycelium growth included
** Strain: A.m. 14/4
*** The dry matter weight of the culture medium is reckoned without the weight of the peat

If the protein content of the substrate is examined after harvesting it is found to be higher than usual. Thus, it seems that the mycelium incorporates the ammonium nitrogen into the protein (Table 25). A substrate like this with a higher protein content is more suitable for feeding to animals.

On the other hand, the ammonium salts have the disadvantage, in the case of surface inoculation, that the fruiting bodies appear later, resulting in a longer production period.

Utilization of nitrates

In synthetic nutrient solutions this *Agaricus* species, like others, is unable to utilize nitrates (Table 26).

Different results were obtained when nitrate utilization was examined in a natural basic material. For this purpose sufficient ammonium nitrate was added to the usual culture medium,

Table 23

Organic nitrogen sources and the yield
Basic material: cob-grist. Inoculum: wheat grain spawn inoculated with strain 14/3. Date of observation: 90 days after inoculation

Date of inoculation	Number of replications	Nitrogen sources	Yield, %
14.XI.70.	6	10% soya meal	113
11.X.73.	2	15% dried malt germ	107
13.VII.73.	4	5% soya meal + 10% dried malt germ	112
21.VII.73.	4		112
14.VI.74.	2		96
18.XII.72.	2	5% soya meal + 10% lucerne meal	110
11.X.73.	3		126
17.I.74.	2		102
31.I.74.	4		106
10.VII.74.	2		117
18.XII.72.	2	5% soya meal + 5% lucerne meal	71

Table 24

Ammonium salts and percentage yield

Date of inoculation	Number of replications	Nitrogen sources and their quantity per pot	Amount and composition of culture medium per pot	Number of days from inoculation	Yield, %
19.II.74.	3	3 g ammonium sulphate	100 g cob-grist 1 g mineral salt mixture	90	69
19.III.74.	1	5 g ammonium sulphate	3 g pulverized $CaCO_3$ 400 ml hot water	90	78
17.VII.70.	2	1.5 g ammonium nitrate 5 g soya meal		95	90
2.XI.73.	1	1.5 g ammonium nitrate		90	83
7.III.74.	3	15 g organic nitrogen source		90	92
29.III.74.	3			90	93
20.I.76.	2	1.2 g ammonium sulphate	20 g chopped wheat straw	65	99
20.I.76.	2		20 g wheat straw meal	75	114
29.III.76.	2		2.4 g $CaCO_3$ powder	50	109
29.III.77.	4		0.4 g mineral salt mixture	80	100
9.IV.77.	4		1 g dipotassium hydrophosphate	90	107
27.V.77.	2		24 g acidic peat	90	117
2.VI.77.	2		300 ml hot water	65	95
			8 g active inoculum (mixed with the culture medium)		

Table 25

*Protein content of substrate after harvesting**

Date of inoculation	Number of replica-tions	Nitrogen sources and their quantity per pot	Number of days from inocula-tion	Yield, %	Protein	Ammonium nitrogen
					in the substrate after harvesting %	
7.III.74.	3	1.5 g ammonium nitrate	90	92	8.3	
29.III.74.	3	15 g organic nitrogen source (10 g lucerne meal + 5 g soya meal)	90	93	9.9—11.6	0.06—0.026

* The chemical analyses were performed by the National Agricultural Quality Testing Institute

Table 26

Nitrate utilization
Treschow culture solution modified with 0.2% agar-agar;
50 ml solution in each 100 ml flask.
Incubation for 20 days at 23.5—25°C. Number of replications: 4

Nitrates	N %	Dry matter weight of the mycelium, mg
Sodium nitrate		0
Potassium nitrate	0.021	4
Ammonium nitrate		57

containing cob-grist as basic material and 15% organic nitrogen, to give a nitrate nitrogen content of 0.96 g per 100 g dry matter. After 100 days of mycelium growth the quantity of nitrate nitrogen fell to 0.26 g, approximately one-quarter of the initial amount.*

Characteristic features of pure cultures

It is a characteristic feature of the mycelium of *Agaricus macrosporoides* that the strands appear soon after inoculation, after which the fruiting body primordia develop on them singly or in groups. These also appear on various culture media and in test tubes also; in addition to the culture substrates malt extract agar, Treschow's synthetic culture medium, wheat and oat culture media and wisps of hay were examined.

In test tubes the primordia remain alive for months. They develop just as well in monospore and multispore cultures. In some of the 20 monospore cultures examined fewer primordia appeared, and in others more. New primordia may appear later, when the culture is several months old; on malt extract agar kept at room temperature they were produced even after 7—9 months. When these fresh primordia developing in old cultures were used for inoculation no deterioration was observed in the new cultures. In the course of mushroom production ini-

* The analysis was performed by the National Agricultural Quality Testing Institu

tiated with fresh primordia obtained from an 8-month-old culture, the yield amounted to 91% of the dry weight of the basic material, compared to a 90% yield in the control series.

By utilizing primordia the cultivation material can be renewed. Fortunately, the investigations made so far indicate that in multispore cultures repeated mycelium inoculation does not result in the deterioration of the cultures. For example, in strain 14/3 inoculation once a month did not generally cause any change up to the end of the fifth year. The monospore cultures are less stable; after a year 10% of them lost their capacity to produce primordia. The mycelium then developed a cotton-wool texture and, naturally, could not be brought to produce fruiting bodies.

Pure culture material

The culture medium is 3% malt extract agar. The cultures are stored either at room temperature with inoculation once a month, or in a refrigerator. Cultures stored for 340 days in a refrigerator without repeated inoculation produced the usual yield (112%; number of replications: 4). The strains which are currently available are shown in Table 27.

Table 27

Strains available at present

Name	Origin
A.m. 14/3	12. 5. 54. Fruiting body collected at Hortobágy
A.m. 14/4	12. VI. 74. Fruiting body grown in laboratory
A.m. 14/74	24. VI. 74. Fruiting body collected at Hortobágy
Sp. 1	5. IV. 71. Monospore culture
Sp. 2	2. VI. 71. Monospore culture
Sp. 3	2. VI. 71. Monospore culture
Sp. 4	2. VI. 71. Monospore culture
Sp. 5	2. VI. 71. Monospore culture
Sp. 6	2. VI. 71. Monospore culture
Sp. 9	2. VI. 71. Monospore culture
Sp. 10	2. VI. 71. Monospore culture
Sp. 11	16. XI. 71. Monospore culture
Sp. 12	16. XI. 71. Monospore culture
Sp. 13	16. XI. 71. Monospore culture
Sp. 14	16. XI. 71. Monospore culture
Sp. 15	16. XI. 71. Monospore culture
Sp. 16	16. XI. 71. Monospore culture
Sp. 17	16. XI. 71. Monospore culture
Sp. 18	16. XI. 71. Monospore culture
Sp. 19	16. XI. 71. Monospore culture
Sp. 21	16. XI. 71. Monospore culture
Sp. 22	16. XI. 71. Monospore culture
A.m. 20	16. XI. 71. Multispore culture

Spawn

The wisp and grain spawn used in two-spore champignon cultivation can be used as inocula. Wheat, cob-grist and oat spawn also proved suitable, while millet and sorghum were not good enough, and barley spawn could not be used at all.

Moderately thick hemp string, previously soaked, then enriched with malt extract and cut into small pieces, was also found to be a good spawn material.

To prevent deterioration, or more precisely, a decrease in yield, it is advisable to use a malt extract agar culture for each third inoculation.

According to examinations concerning storability, wheat grain spawn kept at room temperature proved to be good even after 70 days. Some examples are shown in Table 28.

Storage in a refrigerator for a longer or shorter time — though obviously dependent on the strain — does not influence the yield (Table 29).

Table 28

Storability of wheat grain spawn
Strain No. 14/3

Date of inoculation	Storage at room temperature, days	Yield in the 90 days after inoculation, %	Number of replications
17.I.74.	65	102	1
	15	95	1
23.I.74.	72	120	1
	5	91	1
25.I.74.	74	128	1
	7	94	1

Table 29

Yield produced with wheat grain stored in refrigerator at 2—5°C

Date of inoculation	Strains	Storage in refrigerator, days	Yield in the 90 days after inoculation, %	Number of replications
15. II. 75.	14/3	30	114	1
27. VII. 74.	14/4	15	94	2
31. X. 74.		110	100	2
23. V. 74.	A.m. 20	60	89	1

Preparation of inoculation materials

Wheat grain spawn (after Lemke, modified). The grain is cooked in water acidified with sulphuric acid (0.55 ml concentrated sulphuric acid per 1 litre of water) over a low flame for 15 minutes, kept warm for a further 15 minutes, passed through a sieve or filter (with small quantities the fluid is merely poured off), then sterilized at 111—115°C. If shaken up when warm it will be looser.

Wisp spawn

Wisps of onion-couch-grass or other hay is cooked for half an hour in water (otherwise mycelium growth will be slow), dried, soaked in a 3% solution of malt extract (the pots should also contain a little of the solution, because the wisp absorbs some of it during sterilization), and sterilized at 120°C.

String spawn

Moderately thick hemp string is soaked in water for 2 days, dried, then soaked again in a 2% solution of malt extract (a little of the solution should be put into the pots because the string absorbs it during sterilization), and finally sterilized at about 115°C.

Cob-grist spawn

1000 g culture medium (710 g cob-grist, 170 g dry acidic peat, 71 g lucerne meal, 35 g soya meal, 7 g mineral salt mixture, 7 g potassium dihydrophosphate) is mixed with 2830 ml hot water. Half an hour later it is poured in a 8—9 cm thick layer into pots furnished with cotton air-filters, sterilized for one to one and a half hours at about 115°C. Cob-grist spawn is smeared or wheat grain spawn poured over the surface under almost germ-free conditions. Mycelium growth should take place at a temperature of about 25°C, and storage at the same temperature.

Order of inoculation materials: malt agar culture — wheat grain spawn — cob-grist spawn — cob-grist spawn (inoculation by covering the surface).

Experiments with active inoculators

Cultures where mycelium growth is complete and fruiting bodies are about to be formed are considered to be active. If fruiting body formation is prevented by storing the cultures at 25°C they remain active for a longer time. Such spawn proved to be good even after 45 days of storage and gave outstanding results (Table 21). Mycelium growth begins almost immediately after inoculation, and when the spawn is mixed with the culture medium, interlacing is often virtually complete within five days. However, the growth of the mycelium only proceeds at this pace when the culture medium is sufficiently airy, e.g. if it contains straw as basic material.

The active inocula may contain cob-grist as basic material (ground to a maximum size of 4 mm), or can be made of finely chopped straw. The quantity of inocula is about 5%. In the case of mechanical mixing this amount can probably be reduced. Mechanical mixing makes the even distribution of moist inoculum in the culture medium possible.

Mycelium, fruiting body, and moulds and other pathogens

When sterile cultures of the strains used so far were opened, in an atmosphere of 90—100 % relative humidity no moulds were found on the living mycelium or fruiting body, nor were they attacked by pathogens. This defensive ability on the part of *Agaricus macrosporoides* facilitated the carrying out of the experiments.

Table 30

Fruiting body formation in taxa more or less closely related to Agaricus macrosporoides using the culture medium and method also used for Agaricus macrosporoides

Taxon Site of origin Year of collection	Year of examination	Yield	Are there mould infections on the opened cultures?
A. osecanus Pilát, Hortobágy, 1974	1974	Ø	not examined
A. fissuratus (Moell.) Moell., Debrecen district, spring 1960	1970	Ø	yes
A. fissuratus (Moell.) Moell., Debrecen district, autumn 1960	1970	Ø	yes
A. arvensis Schff. ex Fr. var. *umbrelloideus* Bohus, Békésszentandrás, 1974	1974	Ø	not examined
A. excellens (Moell.) Moell., Buda hills, 1969	1971	Ø	yes
A. excellens (Moell.) Moell., Buda hills, 1970	1970	+*	yes
A. macrosporoides Bohus, a strain which has lost its capacity to produce fruiting body and strands	1970	Ø	yes

* In 2 cultures 2 compact fruiting bodies developed (31 and 73 g, respectively). Their development was slow

On the other hand, in strains which had lost the capacity of fruiting body formation, moulds settled on the substrate after the mycelium had penetrated it (Table 30). Thus, deterioration also affected the defensive ability.

When studying this question in taxa more or less closely related to *Agaricus macrosporoides* this defensive ability against moulds was found to be missing in several cases (Table 30). In the cultures included in this study mycelium growth through the culture medium was also slower than in the case of *Agaricus macrosporoides.*

Experiments with non-sterile culture media made microbially selective

Agaricus bisporus, which often appears in nature on manure heaps, is known to live in populations of thermophilous bacteria and actinomycetes; it is thus obvious that artificially heat-treated culture media with their more or less similar microflora create conditions favourable for it. Although the habitat and living conditions of *Agaricus macrosporoides* are essentially different, so that this method of cultivation did not promise much success, nevertheless, considering the results attained with *Pleurotus ostreatus*, a fungus similarly different in its way of life, 67 types of heat treated culture media were tested. The variations were achieved by using culture media of different compositions, treatments which influence the structure of the microflora, and fermentation at temperatures ranging from 45 to 70°C and for various lengths of time. If the culture media were also sterilized, this was carried out before or after fermentation. Most of the ideas came from Ede Véssey, who also prepared the straw juices containing the thermophilous microflora.

Fruiting body formation was observed in 8 series. Two of them, in which a yield of 62 and 70%, respectively, was produced in 90 days, are presented in Table 31. In the rest the yield was poor, only 11—47%. Records of the experiments are available for all the series.

Table 31

Yield on heat-treated culture media

Date of inoculation	Composition of the culture medium	Treatment	Temperature and period of fermentation	Temperature of steriliza-tion, °C	Yield, %
29.I.74.	100 g cob-grist 10 g lucerne meal 5 g soya meal 1 g mineral salt 330 ml acidified water	Mixed with 100 ml straw juice after sterilization	57° 24 hours	120°	70
15.III.74.	100 g cob-grist 10 g lucerne meal 5 g soya meal 1 g mineral salt 300 ml water	Mixed with 100 ml straw juice after sterilization	57° 24 hours	111°	62

A technological model for farm-scale mushroom cultivation

A culture medium was sterilized at 115°C in vessels furnished with a cover and an air-filter. Active cob-grist spawn was spread over the surface under germ deficient conditions. Mycelium growth throughout the culture medium took place in 20 days at a temperature of about 25°C and a relative humidity of 90%. Fruiting bodies were produced at a temperature fluctuating between 16 and 19°C and a relative humidity of 95—100%. The yield became near equal to the dry matter weight of the culture medium 70 days after inoculation. The composition of the culture medium was: 86% cob-grist, 8.6% lucerne meal, 4.3% soya meal, 0.9% mineral premix, 325% hot water. Water absorption took half an hour.

The results of experiments made using this method are shown in Table 32.

Table 32

Laboratory experiment using method designed for farm-scale cultivation

Date of inoculation	Number of replications	Storage of spawn at 25°C Number of days	Mycelium growth + fruiting body production Total number of days	Yield, %
9. IV. 75.	1	14	77	114
16. I. 76.	3	28	70	114
21. II. 76.	1	6	77	105
9. III. 76.	1	23	90	134

Prepared at the Botanical Department of the Hungarian Natural History Museum, Budapest.

G. BOHUS

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BIOPOLYMER-METAL COMPLEX SYSTEMS
V. PMR INVESTIGATION OF HUMIC SUBSTANCES

Proton magnetic resonance (PMR) and nuclear quadrupole relaxation (NQR) measurements are very efficient methods for the structure elucidation of biopolymers, e.g. proteins, nucleic acids, polysaccharides, lignins, etc. (GLASSER *et al.* 1973, LUDWIG 1971, LUDWIG *et al.* 1964, VON NIMZ 1974, ROSE 1974, ROWE *et al.* 1970).

The study of PMR spectra of humic substances has not received much attention so far, probably due to the complexity and poor solubility of these substances in organic solvents. The PMR spectra of methylated fulvic acid fractions of carbon tetrachloride and deuterated chloroform solution were first examined by BARTON—SCHNITZER (1963) and by SCHNITZER—SKINNER (1968), who observed neither aromatic nor olefine proton signals in the patterns. The presence of aliphatic and aromatic protons and lactone structure in the 60 MHz PMR spectra of a deuterated dimethyl sulphoxide-(d_6) solution of bog peat humic acids was suggested by Japanese authors (OKA *et al.* 1969). German researchers (LÜDEMANN *et al.* 1973) compared PMR spectra of lignin, synthetized hydrochinone and brenzcatechin humic acids with those of peat, humus podsol and brown coal humic acids.

NQR measurements of ^{85}Rb and ^{35}Cl were performed by LINDQUIST—LINDMAN (1969) and LINDMAN—LINDQUIST (1969) in the presence of biopolymers, humic acids and proteins. Considerable broadening of the ^{85}Rb NMR line was observed in the spectrum of an aqueous solution of rubidium hydroxide (5 mole) andrubidium chloride (0.5 mole), containing peat pyrohumic acid extracted with 0.1 M sodium pyrophosphate at pH = 7. The extent of broadening showed marked differences, depending on the soil and humic acid fraction studied. For iron humus podsol ($A_{1,2}$, Lerbäck, Sweden), where the number of rubidium ion bound to humic acids is much lower than the total number of rubidium ions (0.5 mole RbCl concentration), line width broadening was found to be a linear function of humic acid concentration. Within a certain range, the extent of broadening is directly proportional to the pH- value and the addition of hydrogen ions nearly eliminates line width broadening prior to the precipitation of humic acids. The increase of line width can be explained by the ionic bonding of hydrated rubidium ions to polyelectrolyte anions or to their negatively charged functional groups (e.g. carboxyl groups). Through interaction between this modified electric field gradient at the site of ^{85}Rb and the electric quadrupole moment of the ^{85}Rb nucleus, the width of the magnetic resonance signal increases with the increase of the relaxation rate. In experiments carried out with ^{133}Cs, no broadening could be detected on the addition of humic acids. This suggests that interaction between the magnetic moment of ^{85}Rb and the electron spins of the humate ion is not the main factor inducing relaxation, since ^{133}Cs has a much higher magnetic moment than ^{85}Rb but its electric nuclear quadrupole moment is negligible in comparison. Artificial humic acids show a very similar behaviour, although NMR investigations revealed no broadening of the ^{35}Cl on the addition of humic acids. This points to the very important observation that chloride ions are not attached, or at least not chemically bound, to humate anions, which is consistent with the fact that humic acids have practically no anion exchange capacity (see No. VII of this series). It should be noted that the experiments were carried out with low protein content pyrohumic acids isolated from sodium pyrophosphate. In the presence of proteins (e.g. albumin, lysozyme, ceruloplasmine, chimotrypsine, alcohol dehydrogenase) the NMR signals of ^{35}Cl, ^{81}Br and ^{79}Br appeared. A comparison of this effect with the NQR observed for the corresponding metal proteins (e.g. zinc and alcohol dehydrogenase) led to the conclusion that metal-free proteins are capable of binding halogen ions (ZEPPEZAUER *et al.* 1969). No ^{35}Cl ion is bound, however, to the zinc of horse liver zinc-alcohol dehydrogenase (NORNE *et al.* 1973). The bonding site is represented by an ion-pair bond type brought about by the basic group of the amino acids of protein as in the case of the bond between the anion and strongly basic anion-exchange resins. Proteins, on the other hand, do not bind ^{85}Rb-ions.

PMR spectra were taken on a Varian model XL-100 type spectrometer. The preparation and purification of the fulvic acid and fermentation hymatomelanic acid samples were described in Part I of this series (LAKATOS *et al.* 1974). The PMR spectra of fulvic acid were taken in a solvent mixture of deuterated chloroform and dimethyl sulphoxide-(d_6). Hymatomelanic acids were studied in solutions of deuterated sodium hydroxide and/or dimethyl sulphoxide-

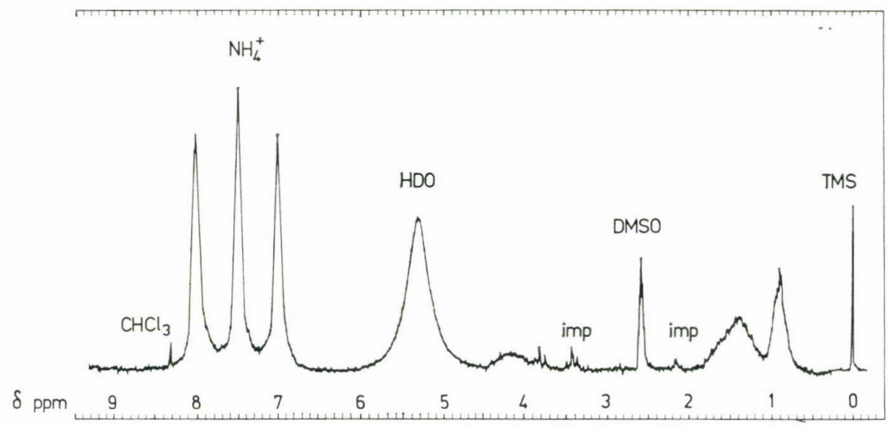

Fig. 1. PMR spectrum of fulvic acid

(d_6). Some samples were subjected to hydrolysis at 105°C for 7 hours in a sealed system, prior to PMR investigations. As a calibration standard, tetramethyl silane (TMS) was used ($\delta = 0$ ppm).

In the 100 MHz PMR spectra of fulvic acid in a mixture of deuterated chloroform and dimethyl sulphoxide (Fig. 1), in addition to the signal at $\delta = 4.2$ ppm further lines could be observed in the range of methyl and methylene groups of aliphatic hydrogens at $\delta = 0.9$ ppm and $\delta = 1.4$ ppm. The signal at $\delta = 4.2$ ppm can be assigned to hydrogen directly bound to the carbon adjacent to the oxygen atom. The triplet in the range of $\delta = 6.9$—8.1 ppm, overlapping the aromatic region, is due to the nitrogen ammonium ion derived from the ammonia used in the preparation of fulvic acid. In addition, further resonance signals of light residues of deuterated solvents and some unidentified impurities (imp.) can also be detected.

The resonance signal at $\delta = 4.2$ ppm in the PMR spectrum of fulvic acid probably points to some lactone structure. In support of this assumption is the observation that as a result of alkaline hydrolysis at 105°C for 7 hours, the signal disappears (Fig. 2). Japanese authors (OKA *et al.* 1969) also observed resonance signals at $\delta = 4.2$ ppm in the PMR spectrum of a hymatomelanic acid fraction dissolved in dimethyl sulphoxide-(d_6). This sample was obtained from humic acid extracted by a mixture of an aqueous solution of sodium hydroxide (1%), sodium acetate (3%) and sodium pyrophosphate (1.8%) from bog peat and/or two different sources of red peat. PMR spectra of the methyl esters of these peat humic acids revealed, however, no resonance signal over the range $\delta = 4-5$ ppm, while the intensity of the signal at $\delta = 3.7$ ppm was twice as high. The PMR spectra of a lactone type compound, e.g. using dihydroisocoumarin as the model compound (JOHNSTON *et al.* 1948), afforded a broad multiplet

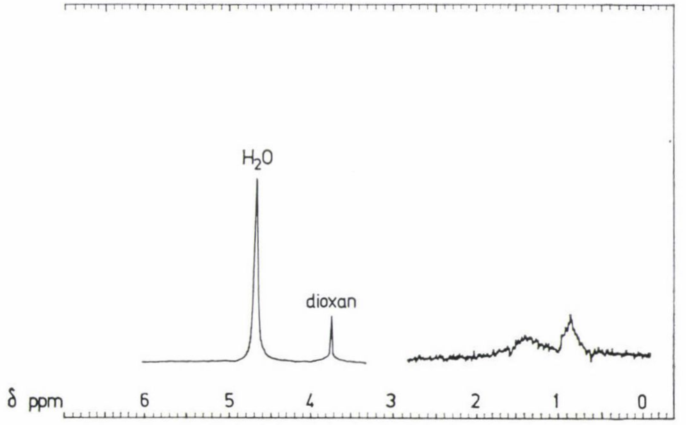

Fig. 2. PMR spectrum of fulvic acid

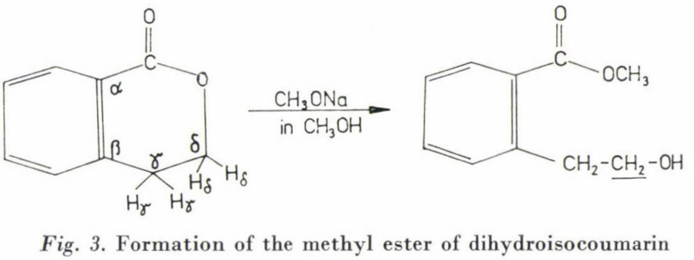

Fig. 3. Formation of the methyl ester of dihydroisocoumarin

at $\delta = 4-5$ ppm, which may be assigned to hydrogen atoms (H_δ) bound to the first carbon adjacent to the oxygen atom. The broad multiplet in the range of $\delta = 3-2$ ppm, on the other hand, may be assigned to hydrogen atoms (H_γ) bound to the second carbon. After preparation of the methyl esters of this compound: (Fig. 3) no signal could be observed in the PMR spectrum in the ranges $\delta = 4-5$ and $\delta = 3-2$ ppm. At $\delta = 3.55$ ppm a higher intensity resonance signal from methyl ester protons and at $\delta = 3.58$ ppm a lower intensity signal from methylene protons could be detected.

The PMR spectra of several lactone type model compounds, e.g. kawalactones (ACHENBACH—REGEL 1973), sesquiterpene lactones (HERZ—INAYAMA 1964, HERZ *et al.* 1963, DE KOCK *et al.* 1968a, DE KOCK *et al* 1968b, ROMO DE VIVAR *et al.* 1966, YOSHIOKA—MABRY 1971) and diterpene acid lactones (GALLUP *et al.* 1968), revealed proton signals of hydrogen bound to the carbon atom adjacent to the lactone oxygen in the range $\delta = 3.0-5.0$ ppm, while in the case of the second carbon atom these signals could be detected in the range $\delta = 3-2$ ppm. PMR spectra of black peat humic acid in deuterated sodium hydroxide solution showed reso-

Table 1

Proton chemical shift of lignin and humic

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Substance	Solvent	Aldehyde			Aromatic protons Guaiacyl		Syringyl	Hetero-aromatic
Lignin	NaOD	8.8 1.2			7.7 2.3	7.15 2.85	7.1 2.9	
Brenzkatechin humic acid	NaOD						7.1 2.9	
Hydrochinone humic acid	NaOD						7.1 2.9	
Fulvic acid	DMSO $CDCl_3$							
Fermentation hymatomelanic acid (from lowland peat)	DMSO NaOD NaOD (105°C, 7h)							
Bog peat hymatomelanic acid	DMSO							6.8 3.2
Red peat humic acid	DMSO							6.7 3.3
Black peat humic acid	NaOD	8.8 1.2			7.5 2.5			
Podsol humic acid	NaOD		2.0 8.0					
Brown coal humic acid	NaOD		2.0 8.0	2.1 7.9				

nance absorption at $\delta = 4.2$ ppm (LÜDEMANN *et al.* 1973). This observation may also be considered due to lactone bonding.

Lactone bonding was first assumed by JURCSIK (1966) on the basis of his chemical investigations on hymatomelanic acids isolated from brown coal humic acids. The PMR spectra of fermentation hymatomelanic acid (LAKATOS *et al.* 1974), on the other hand, revealed no resonance signal over the range $\delta = 4$—5 ppm.

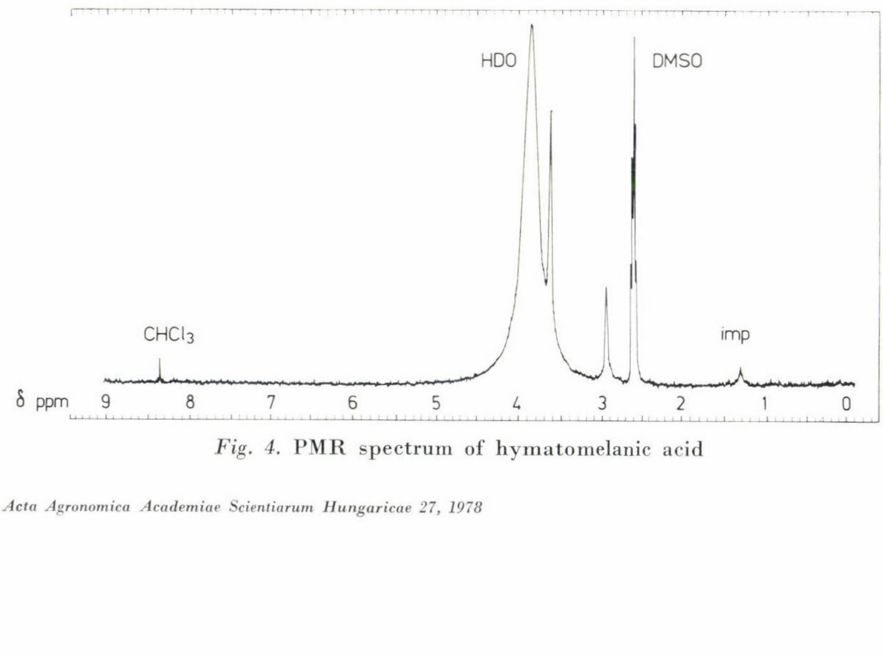

Fig. 4. PMR spectrum of hymatomelanic acid

substances in δ and/or τ ppm values

(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
Lactone H_δ	Poly-sacch.	Ester	CH_3OPh	Aliph. ether	Subst. alcohol	Lactone $H_{\alpha\beta}$	Aliph. carb. acid				Methyl-ene	Methyl
	4.1	3.9	3.7					2.2				
	5.9	6.1	6.3					7.8				
				3.2								
				6.8								
				3.2								
				6.8								
4.2											1.4	0.9
5.8											8.6	9.1
			3.65		2.95							
			6.35		7.05							
		3.85	3.6									
		6.15	6.4									
					3.03		2.47					
					6.97		7.53					
4.2			3.7			2.6					1.3	0.9
5.8			6.3			7.4					8.7	9.1
4.4			3.7			2.6					1.3	0.9
5.6			6.3			7.4					8.7	9.1
4.2		3.9					2.5		1.7		1.3	
5.8		6.1					7.5		8.3		8.7	
	4.1						2.5			1.5		
	5.9						7.5			8.5		
	4.1	3.9					2.5			1.5		
	5.9	6.1					7.5			8.5		

PMR spectra of hymatomelanic acid dissolved in deuterated dimethyl sulphoxide afforded two resonance signals (Fig. 4): a low intensity line at $\delta = 2.95$ ppm and a high intensity signal at $\delta = 3.65$ ppm, which may also be assigned to hydrogen bound to the carbon adjacent to the oxygen atom. PMR spectra of hymatomelanic acid in a solvent mixture of NaOD and D_2O revealed a low intensity signal at $\delta = 3.6$ ppm and a high intensity line at $\delta = 3.85$ ppm (Fig. 5), which may probably be assigned to substituted phenolic methoxy and substituted ester-type compounds and/or their methoxy and ester groups (Table 1). A similar chemical shift can be observed for lignin (LÜDEMANN *et al.* 1973), peat (OKA *et al.* 1969) and brown coal humic acids (LÜDEMANN *et al.* 1973). Both signals disappear, however, after hydrolysis by concentrated sodium hydroxide at 105°C for 7 hours (pH = 14) and two new narrow lines appear (Fig. 6) at chemical shifts of higher intensity ($\delta = 2.47$ ppm) and of lower intensity ($\delta = 3.03$ ppm) (Fig. 6). These signals may be assigned to hydrolysis products: substituted aliphatic acids and substituted alcohols, respectively. No aromatic and olefine proton was found in the PMR spectrum of these products. This observation is in contradiction with the results of IR spectra and the findings of Japanese authors (OKA *et al.* 1969); it is, however, in agreement with the results reported by BARTON—SCHNITZER (1963) and SCHNITZER—SKINNER (1968). The relaxation effect of free electıon spins of hymatomelanic acids may have interfered with the PMR measurements. Further resonance signals are, again, probably due to light residues of deuterated solvents and unidentified impurities.

Probably due to this interference, the PMR spectra of humic acids in a deuterated sodium hydroxide solvent gave no appreciable signals. Data published in the literature on the subject as well as our own experimental results support the assumption of strongly substituted

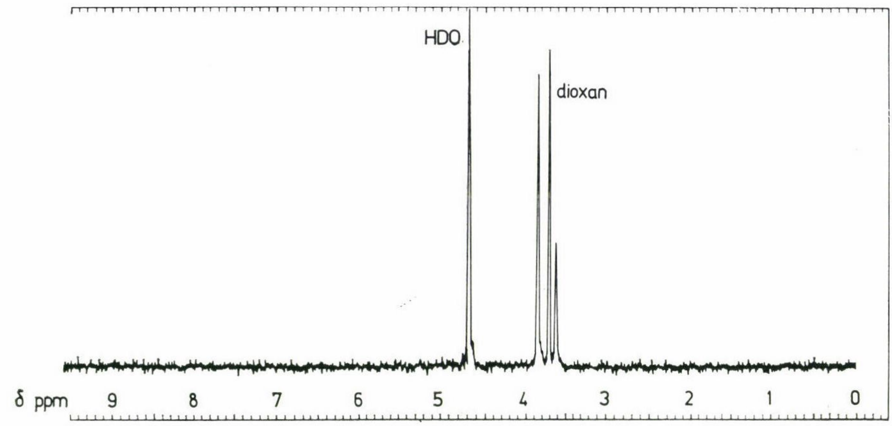

Fig. 5. PMR spectrum of hymatomelanic acid

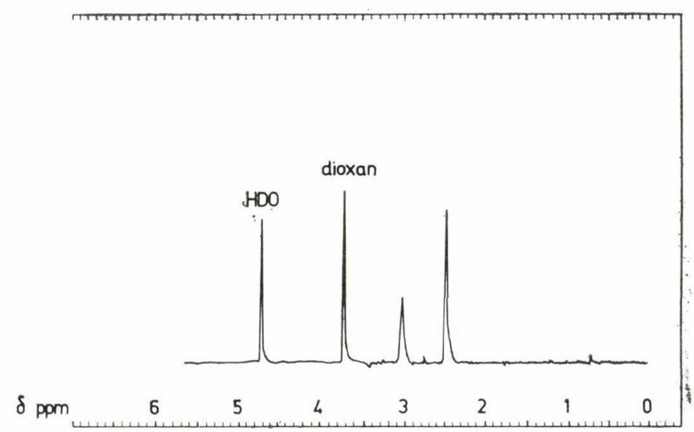

Fig. 6. PMR spectrum of hymatomelanic acid

carbon skeletons in the structure of humic substances, which is in full agreement with the available chemical evidence (ORTIZ DE SERRA—SCHNITZER 1973, SCHNITZER 1975, WILDENHAIN 1969).

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*

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POBITITE KAMENI, THE EOCENE STONE FORESTS OF VARNA

For 130 years attempts have been made to reveal the secret of this world-famous natural phenomenon and some 33 papers and books have been published on the subject, but no acceptable final explanation has been found so far. Some columns were thought to be formed of dripstone and others of coral, the vast cavities were considered to be the results of boring by sea-shells, while certain pieces were taken as the remains of marine algae. These opinions have either been refuted, or the Bulgarians themselves have tried to give some scientific explanation of the phenomenon.

For years the Bulgarian researchers have been offering various explanations, particularly for the size of the regular, cylindrical columns and the way in which the cavities were produced, but their arguments cannot be fully accepted. In 1975 Davitasvili, Georgian academician and Sachariewa, Bulgarian paleontologist, jointly published an important monograph with 115 photos and explanatory drawings, but even they did not arrive at any final result with regard to exactly how and from what these columns developed. In their monograph, written in Bulgarian, the results of the investigations made so far are summed up in English as follow (DAVITASVILI—SACHARIEVA 1975).

"The 'Stone forest', referred to in the Bulgarian literature as Pobitite Kameni, is about 18 km west of the town of Varna, in north-eastern part of the country. The columns of Pobitite Kameni, otherwise called Dikilitash, are preserved in several groups. Almost all of the columns are cylindrical with a central cavity. They are made up of competent calcareous sandstone.

The 'Stone forest' in the vicinity of Varna, with its numerous columns (some of them really gigantic ones) is a grand phenomenon not equalled by any similar assemblages of natural structures found in various countries of the world (Fig. 1).

While most of the columns stand vertically, some of them are somewhat inclined. Columns are as a rule of a circular or subcircular cross section but in some of them it is somewhat elliptical. Some structures resemble umbrellas or huge mushrooms or huge clusters of spherical bodies of various diameters.

A multitude of theories have been expounded to explain the origin of this assemblage of these, mainly columnar, masses of sandstone pillars.

While most of the theories suggest various abiotic factors, only one of them, put forward by V. RADEV, regards the pillars as fossilized corals.

All these theories, including the latter, are criticized in this book and discarded.

The origin of the 'stone forest' of Varna cannot be adequately explained by the action of such factors as erosion, sea abrasion, deflation, etc. Neither can it be interpreted in terms of the stalactitic-stalagmitic or infiltrational theory which is much in vogue at present.

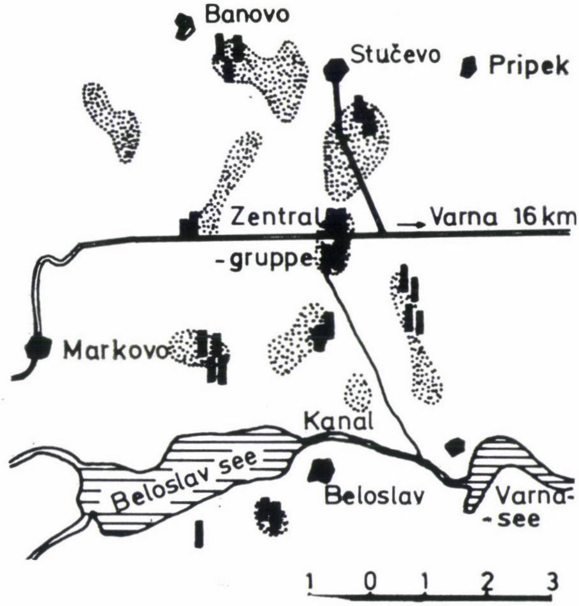


Fig. 1. Sketch map of the stone forest of Varna

The only satisfactory explanation of such a phenomenon regards it as a consequence of the formation of concretions about the trees and other plants after the territory of the forest was invaded by the sea in the Early Eocene."

So much for their results. Although if geologists had called the attention of paleo-botanists to this interesting problem earlier they would have come closer to the solution long ago.

A similar problem was raised by the regular shape and vast, hollow interior of the cylindrical columns, which has struck the researchers most of all.

Sachariewa, the Bulgarian paleontologist, has this to say about them: "Gewaltige cylindrische Säulen bis zur 7 m Höhe und manchmal mit einem Durchmesser bis zur 3 m erheben sich grossartig über der Sandoberfläche" (Sachariewa 1974) (Plate I.). Both in past geological epochs and in the present such regular cylindrical, unbranched trunks have been found only in the tropical sago-trees — *Cycas* sp. (Greguss 1968a) and palms (Greguss 1968b) — but never among pines (Greguss 1955) or dicotyledonous deciduous trees (Greguss 1959). Apart from the *Cycas* sp., only certain palms could come under consideration, but large cavities are never formed in the interior of the latter. So, if these hollow columns are of vegetable origin, that is, they were once arboraceous plants, they must have belonged to *Cycas* sp. It is interesting that nobody has ever thought of these trees, although they offer a starting point and may thus lead to the solution of the problem. The cylindrical trunk of the *Cycas* sp. immediately offered itself as a conclusive similarity, as did the important correlation between the huge pith and the trunk diameter which is, e.g. 38% in *Ceratozamia*, 22% in *Zamia floridana*, 45% in *Dioon edule*, 24% in *D. spinulosum*, and as much as 60% in *Macrozamia moorei*. In Plate II, Fig. 1 the remains of a cylindrical column is seen, and beside it the trunk cross section of an existing *Macrozamia*, which clearly shows that the pith may be as much as 40 cm in diameter (Greguss 1968a). The piths of some fossils were generally about the same size (Plate II, Figs 1 and 2).

The similarity is also apparent as regards height. Some *Cycas* specimens are capable of reaching or even exceeding the 7 m height of the cylindrical stone columns. The Australian

Plate I

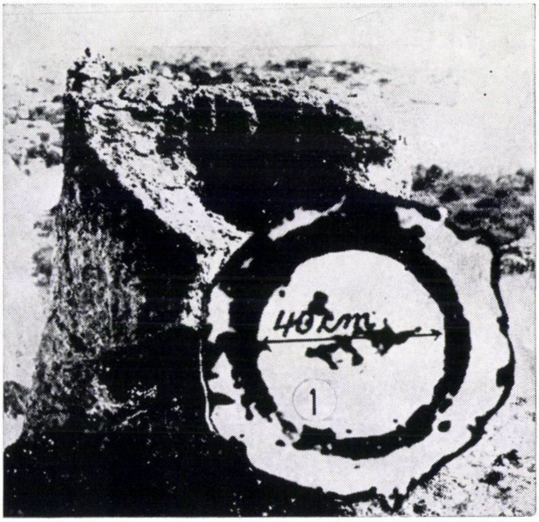
Fig. 1. Landscape detail of the stone forest of Varna. The uniform cylindrical shape of the high columns is apparent

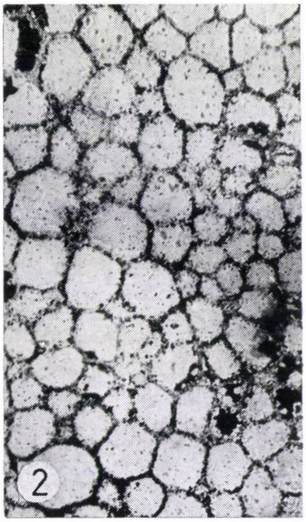
Macrozamia moorei, for example, has a cylindrical trunk 5—7 m in height and 1 m in diameter, while other species may even exceed a height of 20 m. Thus the cylindrical shape and the similar height provide a suitable basis for comparison between the fossils and certain *Cycas* species.

Of another similar phenomenon Sachariewa writes: "Nicht alle Säulen stehen einzeln und manchmal sind sie miteinander verwachsen. Die Verbindungen zwischen den verschiedenen Säulen sind verschieden. Manchmal berühren sie sich mit den Seiten, manchmal kommt es zu einer völligen Vereinigung, so dass doppelte, dreifache oder sogar vierfache Säulen auch entstanden sind" (Plate II, Fig. 3). If all this is applied to the *Cycas* sp. of today the following explanation can be given. Some *Cycas* species have furcate stems or growth tips beneath ground level, which, when they emerge above the soil surface as new stems, are close together, or may even touch one another. In other cases three or four offshoots may grow out of the base of the fully developed trunk, so that they grow almost bush-like side by side, as seen in the case of the South African *Encephalartos longifolius* (Greguss 1955) (Plate II, Fig. 4). From this comparison it can be established again that there is some sort of relation between the fossils and the *Cycas* sp. living today.

Sachariewa and her co-workers did not explain the following observation either: "Einige der Säulen bestehen aus Knollen verschiedener Grösse, welche bei der Witterung der Säulen abbröckeln und umherliegend den Sand bedecken" (Plate III, Fig. 2). This can be explained as follows: Some *Cycas* species living today have the peculiar feature of sometimes developing secondary shoots on the sides of their trunks. These are generally spherical or tuber-like, and, as vegetative sprouts, ensure through abscission the survival of the species (Plate III, Fig. 2).

In her paper Sachariewa writes of a phenomenon that has already caused researchers plenty of headaches. She writes: "Sämtliche Säulen sind bereits von ihrem Grund aus von einer cylindrischen Zentralhöhle durchbohrt". Or in another place: "Es handelt sich um die Zentralhöhle, die sämtliche Säulen vom Grund bis zur Spitze durchbohrt und die das wesentlichste





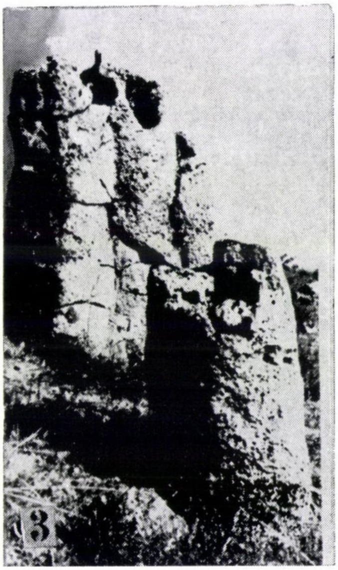


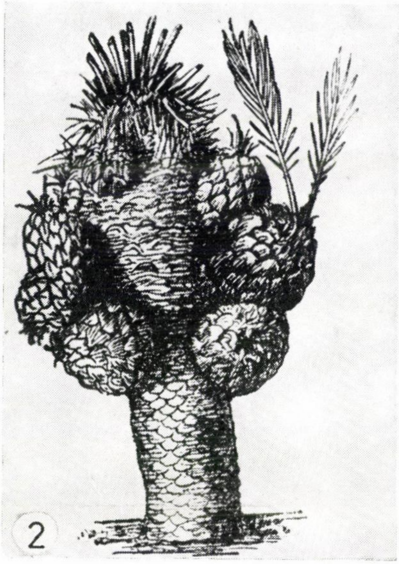
Plate II

Fig. 1. Cross section of trunk in a living gigantic *Macrozamia* of 1 m diameter, with a large pith 40 cm in diameter. The decay of such a pith may have resulted in a cavity. Behind it a vast cavity can be seen in the interior of a fossil trunk

Fig. 2. Parenchyma cells in a pith fragment from a fossil *Cycas* trunk (50 ×)

Fig. 3. Three gigantic hollow columns close to one another, and a broken smaller one in front

Fig. 4. The enormous cylindrical trunks of *Encephalartos longifolius* in South Africa grow similarly close together



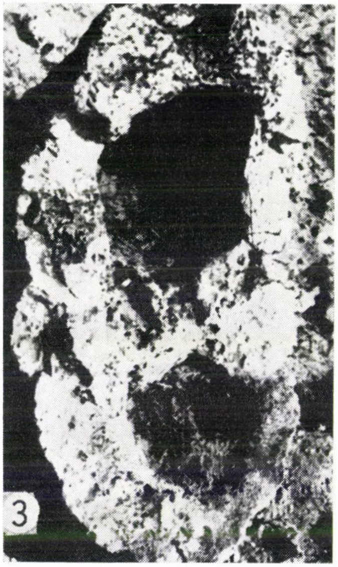


Plate III

Fig. 1. Outgrowths were found on the side of an enormous trunk

Fig. 2. Exactly the same phenomenon is seen on the trunk of a living *Cycas revoluta*. The offshoots on the side of the trunk serve for the vegetative propagation of the plant

Fig. 3. An enormous fossil column has two cavities inside with a separating wall between them. (For explanation see the text)

Fig. 4. Dichotomous *Encephalartos princeps (Cycas)*. At the point where it branches off the central pith also bifurcates

und characteristischeste Merkmal der Säulen ist. Es hat allen Autoren, die sich mit dieser Frage beschäftigen, Schwierigkeiten bereitet. Stücke mit Teredoröhrchen (boring shells) sind eine ausserordentlich häufige Erscheinung in der Gegend der Säulen". This is explained by the following: Of the two cylindrical tree types, the sago palms and the true palms, in the inferior of the latter there is no such medullar structure which, when destroyed, leaves behind a vast uniform cavity. Such a structure occurs only in the *Cycas* sp., whose loose, elderpith-like medulla, if decayed or destroyed, necessarily leaves behind an enormous cavity. Thus, the vast hollows in some of the Varna trees could occur with absolute certainty only in *Cycas* trees (GREGUSS 1968a).

Another — similarly unexplained — observation of theirs can also be easily interpreted. They write: "Bei vielen der Säulen ist der zentraler Hohlraum durch eine vertikale Querwand geteilt. Diese Querwand besteht aus dem gleichen Material aus dem das Steinrohr besteht" (Plate III, Fig. 3).

This phenomenon has a natural explanation. In some *Cycas* species the trunk always shows a dichotomous branching at a certain height (Plate III, Fig. 4). Up to the point where the trunk branches off there is only a single central medullar cylinder in it. From this point onwards, however, in the two lateral branches the pith also continues in two directions (GREGUSS 1955). Above the point of branching the medulla, the bark and the wood in the two lateral branches are necessarily connected merely by a common "Querwand", whose material must be the same as that of the unbranched common trunk. This is why in the fossils two cavities of identical size with a separating "Querwand" between them can be seen. Thus, the role attributed to borers in producing the cavities has no ground at all. Borers are unable to gnaw such regular cylindrical holes in trees.

However, among the nearly 900 photos made by the Bulgarian paleontologist there are some showing columns with no internal cavities. These trees could not be sago palms, only pines or deciduous trees; moreover, small pieces were found whose external and internal structure suggested the former occurrence of huge marine algae.

However, all this could only be finally settled by thorough anatomical studies, as could the question of whether the previous external morphological observations and their interpretation were correct. On the basis of some 30 polished samples obtained in the course of our investigations, we have succeeded in verifying, in a monograph with 35 plates and about 150 photos, that most of the fossils of Varna were decidedly *Cycas* sp., i. e. sago palms, while others were pines or deciduous trees. Finally, marine brown algae also occurred with marine microorganisms on them.

⟶

Plate IV

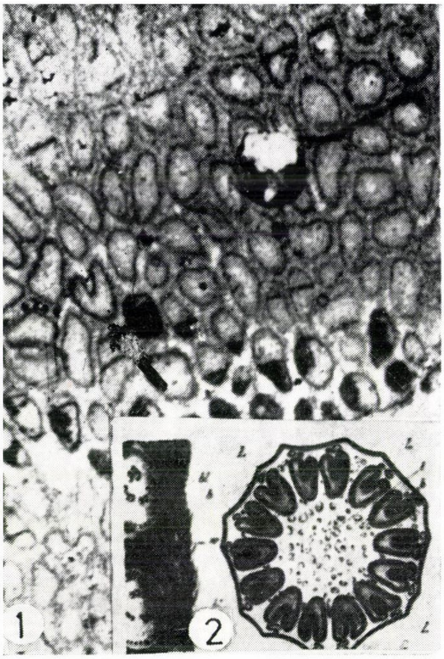
Fig. 1. Protostele bundles in a pith fragment from the fossil trunk of either a *Cycas* or a *Pteridophyta*

Fig. 2. Below in the right corner the cross section of a living *Alsophyla* is seen. Both here and in Fig. 1 the U-shape of the protostele bundles is an ancient pattern. In the middle the large pith, and on the left the outer cortex of the *Alsophyla* are seen (100 ×)

Fig. 3. Cross section of a pine (perhaps *Sequoia*) with three annual zones. The cross sections of tracheids in the annual zones tend to be angular and are arranged in a radial pattern. The medullary rays are one-layered (100 ×)

Fig. 4. Cross section detail from the trunk of a dicotyledonous deciduous tree (possibly *Lauraceae*). The cavernous vessels are isolated, twin-pores or short pore rays. The ground tissue is wood fibre (100 ×)

Fig. 5. Cross section of a cauloid fraction from a large brown alga. Among the diversified cross sections of the highly elongated hyphae the cross section of a sea urchin *(Echinoidea)* can be seen (25 ×)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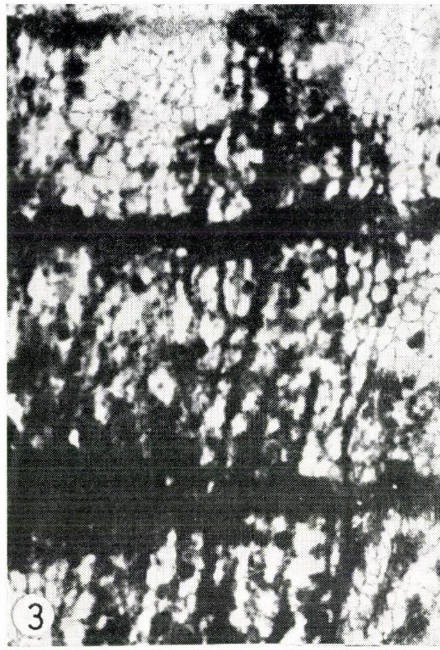
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In several polished samples so-called polysteles were demonstrated which, among the now existing trees, occur only in sago palms (GREGUSS 1968a) or in species closely related to them (OGURA 1938) (Plate IV, Figs 1, 2).

Other polished samples were made from former pine trees (GREGUSS 1955, 1972). The annual rings were clearly visible on them. The tracheids were arranged in a radial pattern with one-layer medullary rays running in between. This kind of structure is found exclusively in pines. One of the polished samples was probably prepared from a *Sequoia* trunk (GREGUSS 1967), clearly showing that in the Varna forests pine trees occurred in the Lower Eocene (Plate IV, Fig. 3).

Another polished sample was made from the trunk — or perhaps branch — of a deciduous tree. It clearly showed that in the inside of the tree the tracheae were isolated, twin-pores or short pore rays (GREGUSS 1968b). Between them the ground tissue was filled in with wood-fibres, wood-parenchyma or tracheids. This structure is only found in deciduous trees. This fossil probably originated from a thermophilous deciduous tree (MAGDEFRAU 1953), possibly a laurel (GREGUSS 1959, 1968c). Thus, in the stone forest of Varna deciduous tree occurred with absolute certainty besides the *Cycas* sp. and pine trees (Plate IV, Fig. 4).

One cylindrical fossil about 4 cm thick may have been a gigantic brown alga *(Laminaria?, Lessonia?, Macrocystis?)* of marine origin (SEWARD 1963). Its inside was not, however, filled up by vessels or tracheids, but by so-called "hypha-like" threads and bundles. Their cross sections differed decidedly from those of the vessels in deciduous trees (Plate IV, Fig. 5. See the explanation of the Plate).

From a scientific point of view this also proved to be a new genus and a new species (*Hyphaites varnense* nov. gen. et sp.; see the explanation to Plate V).

The marine origin is best proved by various marine microorganisms found on the surface and in the interior of the fossils *(Nummulites, Foraminiferae)*, as shown by the figures in Plate VI.

But how were these tiny animals able to penetrate into the cauloid part of the brown alga? In the centre of the 4 cm thick, half-polished cylindrical column signs of a certain degree of former decay were noticed. In all probability the interior of the piece of trunk slowly loosened as it began to decay, so that the microorganisms were easily able to gnaw into it and feed on it. They then remained there after the process of decay was completed.

Dr. Tibor Kecskeméti, the prominent expert on *Nummulites*, identified the microfossils on the basis of photos and sections, and kindly gave further information on them. It was from him that the author learned the marine or brackish water origin of these microfossils, character-

→

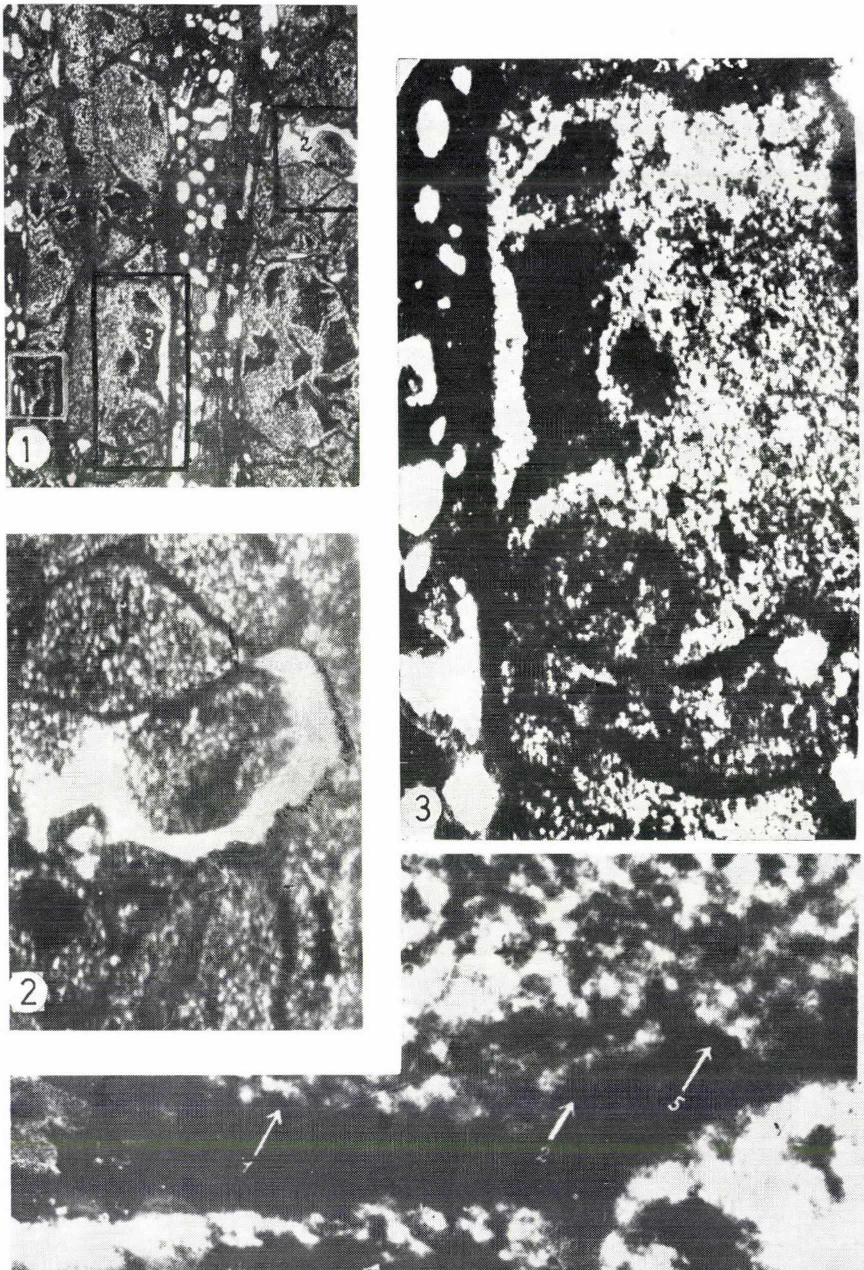
Plate V

Fig. 1. Tall multilayer hypha medullary rays run between the two rows of hypha vessels, which have wide cavities. In the walls of the hypha vessels black openings or indentations of varying shape are found. The warts on the walls are the ends of the thin hyphae composing the vessels. On the right several adjacent openings are found, well separated by double hypha walls (80 ×)

Fig. 2. The crescent-shaped white field in the upper right corner of Fig. 1 shows the wall thickness of a hypha vessel. The uneven lines of the outer and inner walls indicate the boundary of the internal cavity and the outer surface (100 ×)

Fig. 3. Encircled detail from Fig. 1. The tiny white spots are the ends of the thin hyphae (240 ×)

Fig. 4. Encircled detail from bottom left of Figs 1, 2. Arrow 1 shows two interwoven hyphae, arrow 2 a single branching hypha, arrow 3 indicates the ends of hyphae in the wall of the vessel; the same is seen at arrow 5. In other parts of the figure the branching of hyphae in the wall of the vessel are seen (450 ×)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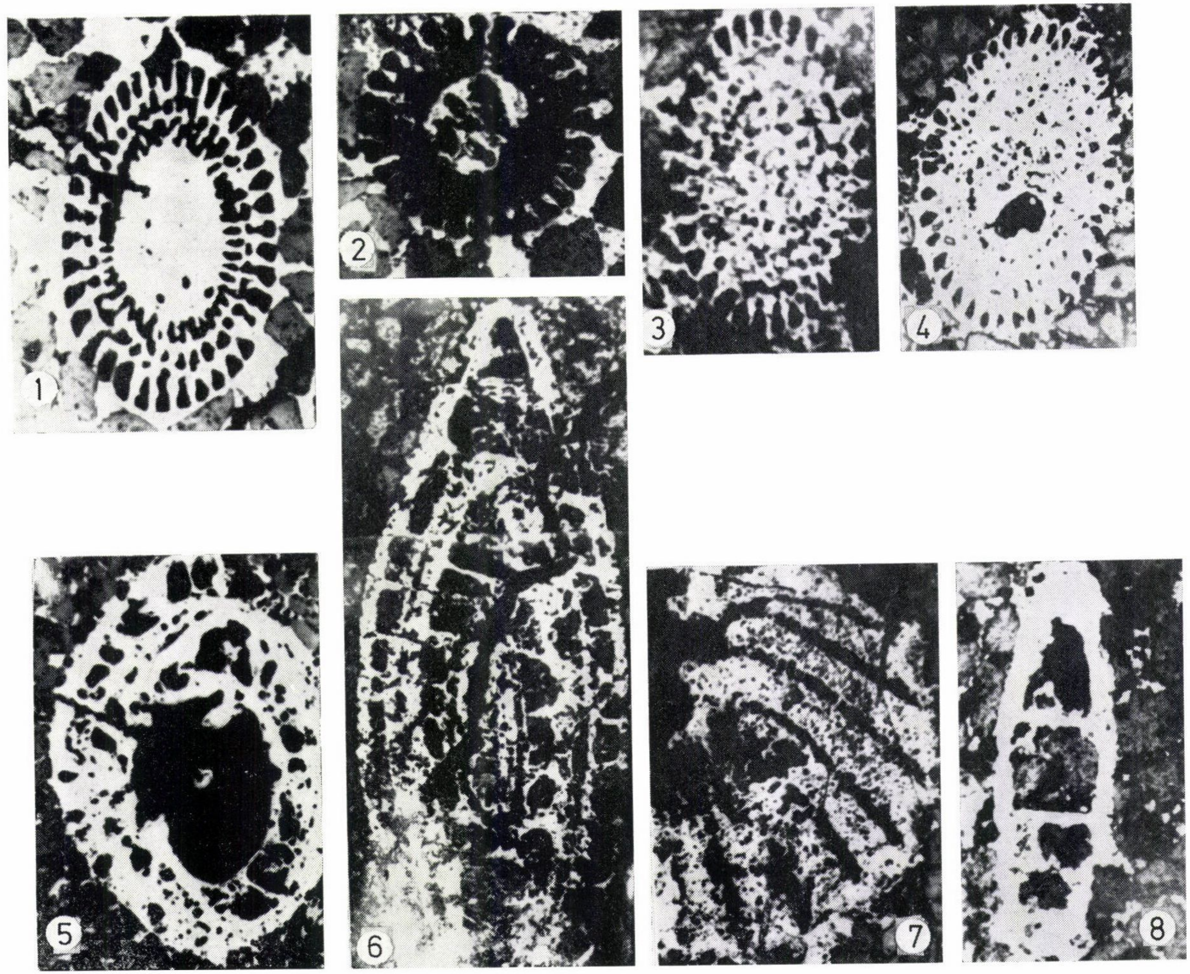

Plate VI

Figs 1—4. Cross sections of various *Echinoidea spines* (30 ×)
Fig. 5. *Foraminifera* (or *Asterigerina ?*) shell (30 ×)
Figs 6—8. Various *Nummulite* shells (30 ×)

istic mainly of the Lower Eocene. According to his statements, fractions of shells of *Nummulites* and — with some reservations — of *Asterigerinae*, as well as of *Foraminiferae*, and spine fractions of *Echinoideae* were found among the microfossils. The *Nummulites* fractions originated from species with primitive shell construction and represented an early phylogenic phase of the *Nummulites* genus. Therefore, the age of the fauna here cannot be considered younger than the Lower Eocene. Among the *Nummulites*, identification closer than the genus was successful only in two cases, and even that went only as far as the lined *Nummulites*. If nothing else their presence proves beyond doubt the temporary presence of the sea. Some of these animals, 1—5 mm in size, are presented (see explanation to Plate VI).

Besides the short information given above many data could be published to prove that in the stone forests of Varna neither coral nor drip-stone occurred, and that the large cavities were not gnawn by borers. We readily accept, however, that external physical and chemical forces played an important role in shaping the columns and other formations throughout millions of years. Thus, in Bulgarian guides to travellers the section concerning the origin of the stone forest of Varna should definitely be modified, as most of it can be traced back with absolute certainty to plant structures. All this has been established with the aid of paleoxylotomy by a Hungarian researcher, who has thus contributed greatly to the solution of this 130 year old problem (Greguss 1968b).

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I express my grateful thanks to Dr. K. Sachariewa, Bulgarian paleontologist, for the landscape photographs of the Varna fossils, to Prof. Gyula Grassely, academician, and Dr. Sándor Gulyás, assistant professor, both former pupils of mine, for making photographs of the microfossils, and to Dr. Tibor Kecskeméti (Hungarian National Museum, Budapest), prominent expert on *Nummulites*, for identifying them. The anatomical photographs were made by the author.

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JÓZSEF SADLER AND THE HUNGARIAN EXSICCATES

(Hungarian Exsiccates. 2.*)

József Sadler, museologist (Fig. 1), who continued the nearly four-decade flora research of Winterl and Kitaibel in the years between 1810 and 1825, botanized untiringly in different parts of Hungary (particularly in the then Pest county, but also in Transdanubia, the Mátra hills, Transylvania and the North and East Carpathians), and also did a lot of collecting in Northern Italy in 1818 and on the coast of Croatia in 1825. Besides his own travels he kept up a correspondence, and above all a lively exchange of herbarium specimens, with many of Europe's prominent botanists. Thus, within a fairly short time he compiled a herbarium of nearly 30,000 pages, which was outstanding in Europe at that time. This material later furnished the basis for the large Hungarian comparative herbarium (JANKA 1880): the collection of European fame in the Hungarian National Museum, later the Museum of Natural Sciences.

Fig. 1. A portrait of József Sadler. The work of an unknown painter. (Property of the Historica Section of the Museum of Natural Sciences.)

* 1.: Bot. Közlem., 1976, **63,** 217—229.

1. Sadler's botanical work

After completing his pharmaceutical studies, and while beginning his medical studies, from 1815 onwards Sadler took a more and more active part in the work of teaching at the Pest University (first with Kitaibel and Schuster, then as Haberle's assistant). Though appointed to the National Museum in 1821, he continued his work at the University. In 1826 he became dean of the Medical Faculty and, after the death of Haberle in 1834, university professor and director of the Botanic Garden. After 1830 he was unable to continue his collecting tours owing to his many and varied commitments, but he did not stop his literary work in botany, and made far-reaching plans to carry on the nation-wide natural history exploration launched by Kitaibel. It was Sadler who published the first exhaustive Hungarian county flora work (SADLER 1825—1826, 1840) and then suggested the compilation and publication of an illustrated floristic work covering the whole country. He also raised the idea of exploring the full natural history of Hungary. For nearly two decades he worked on the preparation of the great Hungarian Flora, employing not only his own numerous observations on nature, his experience in collecting and his immense herbarium, but many of his university students, too. Besides his valuable essays (for example Hungarian pteridophytes, orchids, etc.) some 20 dissertations were completed between 1830 and 1845 with his guidance and help. These monographs by his students, though mostly mere compilations of medical botany (KANITZ 1861—1863, 1865), included some really valuable flora works (e.g. the first compilation of the rich submediterranean flora of the Mecsek hills by Károly Nendtvich (NENDTVICH 1846)).

Sadler performed extensive studies on the history of botany in Hungary in the 16th century (SADLER 1845a), and he was also the initiator of investigations into mineralogy, petrography and paleontology in Hungary (KÁTAI 1865). He was the first person in Hungary to use a microscope in botanical research work.

Sadler had outstanding merits in the botanical exploration of Hungary, and in the construction of the large comparative herbarium. Moreover, he was an extremely efficient organizer and museologist. He proved his excellent qualities in both his university teaching and in popularizing lectures. He was the first lecturer in the Medical Faculty of the University who, as early as March 1841, wanted to deliver his lectures in Hungarian as well as in the traditional languages of instruction, Latin and German (GOMBOCZ 1914: 175). In those days this was a very brave espousal of nationalist views; lectures at the Medical Faculty were only allowed to be held in Hungarian during the 1845/46 school-year, after prolonged negotiations and altercations.

Sadler was granted membership of a number of foreign scientific associations (e.g. Jena, Halle, Regensburg, and the *Naturae Curiosorum* in Moscow). He was a founder, committee member and frequent lecturer of the Royal Hungarian Society of Natural Sciences. His lectures, delivered either at the University or at various professional sessions of the Society, greatly promoted flora research in Hungary, and were of great service to the previously somewhat neglected public education in botany. This applies still more to Sadler's publication of the first Hungarian exsiccates, which received very little recognition.

2. Sadler's two exsiccates

With a view to the development of public education in botany in Hungary, Sadler advanced a highly important plan in 1821: to compile and publish a collection of exsiccated Hungarian plants. He probably planned 8+8 booklets, and to each fascicle (according to Sadler's terminology: "volume") intended to publish a separate interpretative brochure in Hungarian. The first outline of the work, and later the presentation of the individual booklets, were published in the journal "*Flora*" at Regensburg (SADLER—PAUER 1821—1823), then reports appeared

(THAISZ 1823—1824) in the first contemporary Hungarian scientific journal "Tudományos Gyűjtemény" (Scientific Collection). After the completion of the first 8 fascicles in 1824, Sadler added a separate title-sheet, an 8-page preface and indexes to the 8 interpretative brochures. The whole text, which amounted to only 112 pages, can be found in one volume in several Hungarian public libraries even today. The full title is: "Magyarázat a' magyar plánták' szárított gyűjteményéhez. Készítette Szádler Jó'sef . . ." (Explanation of the exsiccated collection of Hungarian plants. Drawn up by Jó'sef Szádler . . .). It is worth noting that this is the only time Sadler used his name in its Hungarian phonetic form.

In contrast to the mentioned booklets, hardly anything is known about the further 8 fascicles. In his fundamental bibliography GOMBOCZ (1939) does not even mention the other 8 booklets; he only writes about them in his history of botany* (GOMBOCZ 1936), and even then only in the foot-note when enumerating the bibliographic data of 14 fascicles. KANITZ (1865: 156) spoke of 16 planned booklets, which were "angekündigt, aber nie erschienen" (announced, but never published). NEILREICH (1866) saw only the first 8 booklets and remarked: "die folgenden Hefte vermochte ich nicht aufzufinden" (I was unable to find the following booklets). Of booklets with serial numbers over 8 only the texts of Nos 9—11 can be found in the library of the Department of Taxonomy, Eötvös Loránd University, bound together with the first 8 booklets. In the Historical Section of the Museum of Natural Sciences a somewhat incomplete series was discovered (together with several duplicates): here booklets Nos 10, 11 and 13 are found. In the herbarium of the Botanical Collection booklet No. 12 was also found. Thus, 13 of the 14 booklets mentioned by Gombocz have been discovered, and only the last one is missing.

Each fascicle ("volume") of the exsiccate contains 25 carefully prepared plant species fixed with adhesive tape to herbarium sheets 19.5×32.5 cm in size. Apart from the damage caused by insects to a few specimens, the plants of the exsiccate are in good condition despite being nearly 150 years old (Fig. 2). On a tiny printed label in the lower right-hand corner of each herbarium sheet the Latin name and habitat of the plant species are indicated. The fascicles (each containing herbarium sheets for 25 species) are covered with blue card-board and bound like books with thin string (Fig. 3). Thus, the fascicles look like thin books (or booklets) and can be placed on library shelves. A label written in Hungarian is stuck on the front of the blue cover indicating the serial number of the "volume", a reference to the medical or agricultural series, the name of the editor (J. Sadler) and the year of publication; for the medicinal plants an additional label in Latin is also found on the cover. Since the year was not indicated on the interpretative brochures, the years written on these labels helped in determining the year of publication for the 14 fascicles of Sadler's exsiccate:

Fascicle	Year of publication
1—4	1823
5—8	1824
Preface and indexes	1824
9—11	1825
12—13	1827
14	1830 (?)

* As may be seen, in the bibliography published three years later Gombocz only listed 8 booklets, compared to the 14 mentioned earlier. This was in all probability due to the fact that Gombocz actually compiled his bibliography between 1910 and 1920, when only 8 booklets were known. Owing to the war, and for other reasons, the bibliography was only published in 1939, whilst his history of botany, a new, more complete work was issued earlier, in 1936.

According to Sadler's original plan, the fascicles would have contained medicinal and agricultural ("oeconomic and technological") species alternately. The former were, however, fewer in number, so only 6 of the 14 booklets (Nos 2, 4, 6, 9, 12 and 14) contained plants of medical value (150 species), while in the other fascicles species which could be utilized in agriculture, industry, horticulture, etc. (including several fungal diseases) are found.

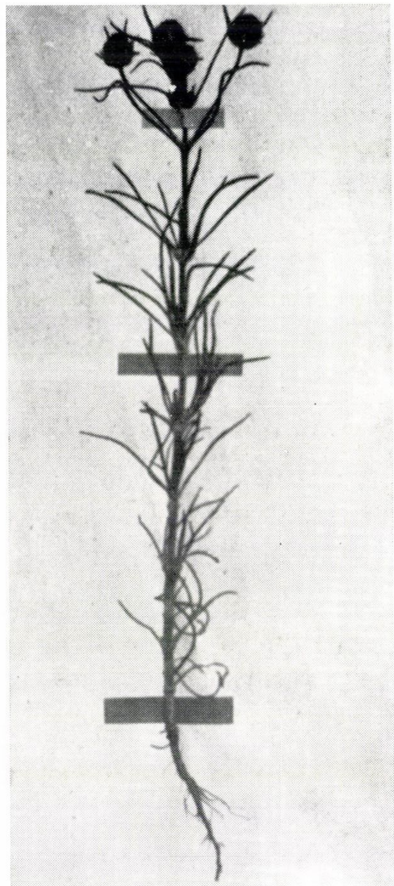

Fig. 2. Herbarium specimen of *Plantago arenaria* W. et K. in the exsiccate

Much less is known of Sadler's other exsiccate, which contained species of *Gramineae*, *Cyperaceae* and *Juncaceae*, but without interpretative texts. It is quite certain that Sadler had long been a close observer and collector of the agriculturally important grasses and sedges occurring in Hungary, of which many traces are found in his herbarium and in the "Explanations" of the above mentioned first exsiccate. His collecting work provided rich material for a more comprehensive paper on *Gramineae* published in Hungarian (SADLER 1845b). It was probably as a preliminary study for this paper that he presented the major species of *Gramineae*, *Cyperaceae* and *Juncaceae* found in Hungary, Croatia and Dalmatia in his second exsiccate for botanists and agriculturists. Very little trace of this exsiccate has remained, beyond a mention of its title by KANITZ (1865: 157) who added: "Exemplare sind noch um ein Thaler bei dem Verleger G. Kilian in Pest zu bekommen". (In other words, a quarter of a century after it had been published copies were still available in Pest.) From WITTSTEIN's book (1852: 779) we learn that Sadler "gibt seit 1836 auch eine *Agrostotheca hungarica* heraus". Finally, besides the full

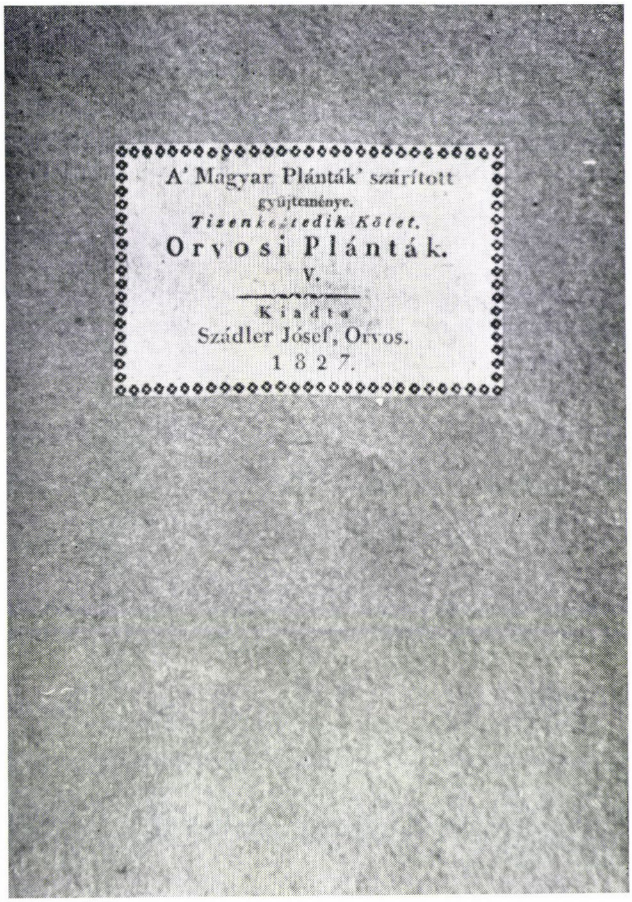

Fig. 3. Jacket for fascicle No. 12 of Sadler's exsiccate

title, GOMBOCZ's history of botany (1936: 441) and his bibliography (1939: 28) give another year, according io which the two-volume folio work "Die Gräser Ungarns . . . *Agrostotheca Hungarica* . . ." was published in 1841. (As for the species number and content, however, no information is given in Gombocz's history of botany.)

The original of Sadler's second exsiccate has not been found so far, but we have found a two-page, folio-form list in manuscript headed "*Agrostotheca hungarica*, editore Jos. Sadler" with no date. It contains the names of 75 plant species, and for some of them also the habitats. It was presumably the species included in this list that Sadler published in the *Agrostotheca*.

Some of the plants (mainly the mountain sedges) are from the High Tatra, while a number of species are from the coast near Fiume.

Valuable data have been found in the Historical and Botanical Sections of the Museum of Natural Sciences concerning both the second and first exsiccates. Thanks are due to Mrs. I. L. Allodiatoris, Mr. J. Ujhelyi and Mr. S. Tóth for their kind help and disinterested collaboration.

Sadler's two exsiccates, which include a total of more than 400 species, served the purpose intended by their author. As pointed out by Gombocz (1936: 441), these collections were still to be found in institutes and schools, even in the 1930's.

Sadler's "Explanations" contain many valuable ethnobotanical data, and — in addition — a long list of Hungarian and German popular plant names from the 1820's, many of them previously unknown. Since these "Explanations", written in Hungarian, have not been dealt with so far by either the botanical or the linguistic literature of Hungary (apart from Nos 1—8, the other booklets were hardly known to exist at all), it seemed to be worth-while summing up these little known data of Sadler's in a separate work (Priszter, in press). The Latin names used by Sadler, which have changed considerably during the last 150 years, together with the full species list of the exsiccates, are treated in another work (Priszter 1976).

3. Hungarian exsiccates published after Sadler

Sadler's pioneer work in publishing the exsiccates has been followed by many others since the 19th century in Hungary, and the private collections were soon followed by large official exsiccates. The latter were no longer published by researchers, who — though highly enthusiastic — were short of adequate financial means, but by the more affluent botanical institutions (mostly large national herbaria).

Since no comprehensive review of these has ever been made in Hungary (and hardly any abroad) a brief outline of the Hungarian exsiccates and of those connected with Hungary is presented below, without any claim to be complete (cf. Priszter 1959: 133—134).

Not much later than Sadler, Gyula Kováts, museologist, published an exsiccate consisting of 15 "centuriae" (part of it edited twice) under the title "Az ausztriai birodalom, különösen Magyarország és Erdély ritkább szárított növényei" (Less frequent exsiccated plants of the Austrian Empire, particularly from Hungary and Transylvania, 1844—1850). Mihály Fuss's Transylvanian exsiccate was published in a much more modest form (*Herbarium Normale Transsilvanicum*. Hermannstadt, 1862—1872; 11 fasc.) The latter can hardly be considered a true exsiccate, since it was made in only 6 copies. In a similar way, those exsiccated plant collections — furnished with printed labels — which originated from longer trips to areas which had hardly been explored botanically can only be regarded as herbarium exchange of some importance. These include, for example, Rochel and Heuffel's plants from Banat (now part of Yugoslavia) (1823, 1833), Szovits's collections from the Ukraine and the Crimean peninsula (Láng 1827), Noé's plants from the Quarnero Bay (1833—1836) and Fiume (1843), and above all the herbarium material of Frivaldszky's highly important Hungarian expeditions to the Balkans (1833—1838).

The often cited "*Flora Exsiccata Austro-Hungarica*" (Kerner—Fritsch 1881—1913), an excellently arranged Austro-Hungarian exsiccated plant collection published in an exemplary form, is of quite a different character. It was compiled by the well-known Anton Kerner, who worked at it until his death. Ten "centuriae" were edited in Vienna in 33 years: the whole series contained 4000 species, nearly a quarter of which originated from Hungary, and the best known Hungarian botanists took part in collecting them.

It was at the beginning of the 20th century that Árpád Degen — with the help of his colleagues at the Seed Testing Institute — started publishing two highly important exsiccates of Hungarian grasses and sedges. "*Gramina Hungarica*" contained 450 taxa in 9 volumes (1900—1914 and 1939), while "*Cyperaceae, Juncaceae . . . Hungaricae Exsiccatae*" contained 280 taxa in 5 volumes (1914—1915 and 1928). It was also at the beginning of this century that "*Flora exsiccata Hungarica*", a separate Hungarian exsiccate, was started as the publication of the Botanical Section of the Hungarian National Museum. The 10 "centuriae" (1000 taxa) issued in 21 years (1912—1932) were a worthy parallel to the above-mentioned Austro-Hungarian collection, and at the same time served as a basis for Jávorka's "*Flora Hungarica*" then in the course of preparation.

All the four exsiccates (the two from the Museum and the two edited by Degen) are of fundamental importance. The carefully compiled collections, which are still usable today, were supplied with valuable labels (schedae), which in the case of the Austro-Hungarian and Hungarian exsiccates were issued in a separate publication (covering nearly 2000 pages; Kerner—Fritsch 1881—1913, Anonymous 1912—32). The collections of Hungarian grasses and sedges were not, unfortunately, treated in the same way, although Degen's labels (schedae) also contained valuable data.

Since the beginning of the 20th century some specific Hungarian exsiccates have been published, mostly on private initiative and — owing to limited financial means — in a modest form. Exsiccates of medicinal plants (Butujás Gy., Kolozsvár, 1910; Augustin B., Budapest, 1929), a collection of the plants of meadows and pastures (Rigler J., Budapest, 1937), and the valuable seed collections in glass ampoules of the Budapest Seed Testing Institute (Tordai Gy.: Gazdasági növények (Field crops); Thaisz L.: Gazdasági gyommagvak (Seeds of weed plants in field crops), 1902; Gerhard G.—Zsák Z.: A magyar búza gyommagvai (Weed seeds of Hungarian wheats) 1936, and A magyar lóhere és lucerna gyommagvai (Weed seeds of Hungarian clovers and lucerne) 1938) were intended for practical purposes. An exsiccate in 22 decorative cardboard boxes prepared by J. Tuzson, A magyar Alföld növényeinek gyűjteménye (Collection of plants from the Great Hungarian Plain). Flora exsiccata Planitiei Hungaricae; 703 species, Budapest, 1929—1937) can be found in many educational institutions even today. An abundance of Hungarian plant material was contained in Zahn's "*Hieraciotheca Europaea*" (Wien, 1906—1910), while J. Wagner's special *Tilia* publication (*Tiliae exsiccatae criticae;* Budapest, 1929—1933, 5 fascicles) was an internationally outstanding collection.

As mentioned above, the first steps towards the publication of cryptogamic plants were taken in Sadler's days. In the "A Magyar Plántäk . . ." (Hungarian plants. . .) 20 cryptogams (ferns and fungal diseases) are found. The Transylvanian mosses were published, in a limited edition, as early as 1871—1873 by J. Barth (Die Laubmoose Siebenbürgens, Clausenburg; 100 species). Half a century after Sadler the experts were presented with valuable mycological material in the collection of Gy. Linhart, a prominent phytopathologist from Magyaróvár (Magyarország gombái. Ungarns Pilze (Mushrooms of Hungary), Magyaróvár, 1882—85; 5 centuria). More than one-fifth (847 species) of the 4000 items of the afore-mentioned Austro-Hungarian exsiccate, and 338 of the 1000 species of the Hungarian exsiccate were cryptogamic plants. The large cryptogam publication *(Kryptogamae exsiccatae)* in which the domestic plant material of many Hungarian collectors was also presented until 1916 (algae, pathogenic fungi, lichens and mosses) was started in Wien in 1903, under the editorship of A. Zahlbruckner, who was of Hungarian origin.

It was in the early 20th century that the parasitic fungi of Hungarian cultivated plants (Pósch K.: *Fungi parasitici exsiccati plantarum cultarum Hungariae*, Grinád, 1902) and the Hungarian moss exsiccate (Győrffy I.—Péterfi M.: *Bryophyta Hungarica exsiccata*, Kolozsvár, 1915—1918) were published. As many as three collections of lichens were edited in the 1930's (Kőfaragó-Gyelnik V.: *Lichenotheca*, 1933—1937; and *Lichenotheca parva*, fasc. I—II, 1937;

Fóriss F.: *Lichenes Bükkenses exsiccati*, fasc. I—II, 1935—1939). After World War II the Botanical Section of the Museum of Natural Sciences continued and completed the edition of *Lichenotheca parva* (fasc. III—V, 1969), and started the series of *Lichenes Exsiccati* (Verseghy K., fasc. I—II, 1969).

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SUNFLOWER AND THE PROBLEM OF UNFILLED SEEDS UNDER SUDAN CONDITIONS

The current literature on the different aspects of empty seeds in sunflower is very limited. LUCIANO *et al.* (1965) and KHANNA (1970) reported that the empty seeds found in a number of sunflower varieties might be due to self-incompatibility, inefficient pollination vectors, insufficient nutrient supply of developing seeds and competition among the sunflower plants.

This study presents the results of the first investigation, under Sudan conditions, on the problem of empty seeds associated with sunflower production.

A sunflower variety field trial was conducted at G.R.S. (G.R.S. = Gezira Research Station, Wad Medani, Sudan) from 1968/69 to 1970/71. The soil is heavy, dark cracking clay with a pH of about 8.5 and a low nitrogen status. The average annual rainfall was 300 mm.

The trial consisted of four varieties: Armavirec, Arrowhead, Manchurian and Peredovic. Sowing was conducted on 1/6 at a spacing of 60 cm between ridges, 20 cm between holes and 3 seeds per hole and the seedling were thinned to 1 plant per hole two weeks after planting. On the day of planting the seeds were treated with Aldrex T at 2.2 g per kg of seeds. The experiment was irrigated at two-week intervals and was weeded twice. All the operations from sowing to harvesting were manually conducted. The design of the experiment was a randomized block replicated six times and the subplot size was 12 m $\times$ 4.2 m. The plants in the central row of each subplot were used for this investigation; 50 plants from each subplot were subjected to individual plant study.

The plants of the remaining middle four ridges were used for yield determination and the study of other agronomic characters. Samples for the 1000-seed-weight and hull percentage were obtained from the seed yield of each subplot, with five determinations per subplot. Five plants per subplot, selected at random, were used for the determination of the weight of unfilled seeds per head and the diameter of the head.

The diameter of the head and the plant height were taken on the day of harvesting. Stem thickness was measured with a vernier calliper 20 cm from the ridge surface on the day of harvesting. Leaf area was determined by the punch borer method (NUR 1971). Hull percentage determination was based on the seed cutter (NUR 1969).

The results achieved in this investigation are based on the correlation coefficient studies.

Table 1 indicates the positive and very highly significant ($P < 0.01$) correlation coefficient (r) between the percentage of unfilled seeds per head and each of: days to maturity, plant height, stem thickness, diameter of the head, leaf area per plant and hull percentage of seeds obtained from the centre of the head of sunflower plants.

Table 1

Coefficient of correlation (r-) values between the percentage of unfilled seeds and various other characters

Days to maturity	+0.78**
Plant height	+0.80**
Stem thickness	+0.80**
Diameter of the head	+0.87**
Leaf area per plant	+0.84**
Hull percentage of seeds obtained from the centre of the head	+0.83**

** $P < 0.01$

Table 2

Sunflower varietal differences

Variety	Seed yield, kg/ha	1000-seed weight (g)	Hull percentage	Weight of unfilled seeds per head (g)	Head diameter (cm)
Armavirec	262	52.2	26.3	1.8	8.4
Arrowhead	404	59.9	37.1	2.5	9.2
Peredovic	354	55.8	29.4	2.1	8.9
Manchurian	476	74.2	46.8	3.5	10.7
S.E.	$\pm$15.83	$\pm$1.20	$\pm$0.96	$\pm$0.11	$\pm$0.16

It was observed that the late maturing plants resulted in taller plants, increased leaf area, larger heads and thicker stems. The status of these characters might have been attained on account of the greater percentage of unfilled seeds as the plants used the available nutrients for more vegetative growth than for seed development. Theoretically, plants with thicker stems have the potentiality for more nutrient supply and increased total leaf area, thereby resulting in more seed development. But the results obtained in this study are contrary to this theory.

The florets of sunflower do not open at the same time and those that open last are rarely visited in time by the bees. This might be the reason for the case where plants having larger heads also had a greater percentage of unfilled seeds.

It was noticed that the unfilled seeds were located in the centre of the head; this might be due to the fact that the florets farthest from the periphery of the head are the last to open. And because of competition for nutrient supply in the head, the florets that are last to open are left with little nutrient supply, resulting in less developed seeds, consisting mainly of seed coat and pericarp and no cotyledon oil-bearing tissue.

Sunflower seed usually consists of hull and meat. The hull is composed of the seed coat and the pericarp, the meat is composed of the cotyledon oil-bearing tissue. The high hull content handicaps the production of sunflower commercially as it reduces the oil and protein content of the meat.

The varieties differed significantly in each of the agronomic characters tested, as shown in Table 2.

The results obtained in this study could serve as a guide-line in breeding programmes for new lines and for agronomical trials in sunflower production.

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GENETIC DIVERGENCE IN CHICK-PEAS (CICER ARIETINUM L.)

Analysis for genetic divergence in pulse crops is available in studies by GUPTA—SINGH (1971) in mungbean, by ASAWA—ASAWA (1976) in red gram, by MALHOTRA—SINGH (1971) in black gram and by MAHENDRITTA—SINGH (1971) in cowpea. Of late, considerable attention has also been paid to the study of divergence in segregating populations (RAMANUJAM *et al.* 1974 in mungbean). Unfortunately, no such report is available for chick-peas, which is the most commonly cultivated pulse crop. The study of genetic divergence in segregating populations helps in measuring genetic characters and in locating potential parents among a number of unidentified genotypes, released through segregation. As also explored by MILLER—RAWLINGS (1967), intercrossing in early generations can dissipate linkage disequilibrium. It was with this in view, that a study of genetic divergence was undertaken in order to collect information of this nature.

The material consisted of a 5×5 diallel set (excluding reciprocals), grown in 6 replications of an RBD layout in the F_2. From each plot, 10 plants were harvested and bulked. Bulks with a high yield were further bulked within each cross. This material was sown with the parents in the F_3 in 3 replications of an RBD layout. Data were collected on 10 random plants for 11 characters per plot and were subjected to a genetic divergence study, as suggested by MAHALNOBIS (1936), following a highly significant value of χ^2 to satisfy Wilk's λ criterion.

Table 1 shows the salient features of the varieties, incorporated in the diallel set. It is important to note that these varieties were chosen for their seed characteristics and had uniform maturity.

Figure 1 gives the configuration of different clusters and the varieties included in different clusters. All parents and their crosses could be included in 6 different clusters.

Cluster I included JG-62, JG-6 × JG-2 and JG-6 × Pink-2. Parent JG-6 was the most divergent of all the genotypes included in this study. JG-19 was closer to JG-62 × JG-19 and JG-62 × JG-2, while Pink-2, JG-62 × Pink-2 and JG-6 × JG-19 were together in one cluster. Thus, it will be seen that not only were parents in different clusters, but their hybrid derivatives were also in different clusters. Only transgressive segregation could be held responsible for this behaviour of the crosses. Great variability, released due to the divergence originally present in the parents, followed by selection, has resulted in differently constituted genetic pools, quite different to their own ancestors. The experience at this station (College of Agriculture, JNKVV, Jabalpur, INDIA) has shown that whenever a "deshi" gram or chick-pea is crossed with a "kabuli" variety, "gulabi"-or pink-coloured seed is observed among the progeny. Alternatively, the origin of pink seeded varieties could be crossed in nature with the preservation of this type of progeny. It can be seen that cluster IV included the pink seeded parent, one cross involving

Table 1

Salient features of the varieties

Varieties	Sources	Flower colour	Seed colour	Seed size
JG-2	IARI germ plasm	Violet	Green	Medium
JG-6	IARI germ plasm	Violet	Black	Medium
JG-19	IARI germ plasm	White	Kabuli	Medium bold
JG-62	Khargoan (Central India) (double podded mutant)	Violet	Brown	Medium
Pink-2	Ujjain (Central India)	White	Pink	Medium

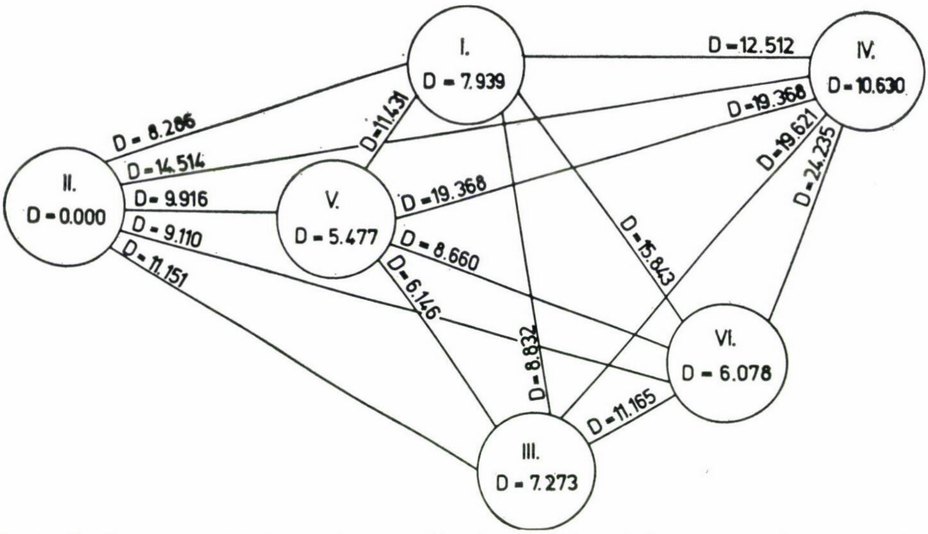

Fig. 1. Configuration of different clusters. (D-values within a circle represent divergence within the cluster while those outside represent divergence in relation to other clusters.)

Table 2

Contribution of different characters to divergence

(1) Characters	(2) No. of times ranked first in divergence estimated	(3) % of all D_2 values in (2)
1. Spread (cm)	3	2.857
2. Height (cm)	4	3.810
3. Pod bearing length (cm)	2	1.905
4. Primary branches	0	0.000
5. Secondary branches	8	7.619
6. No. of pods	10	9.524
7. No. of seeds	0	0.000
8. Seed weight (g)	63	60.000
9. Days to flowering	5	4.762
10. Days to maturity	0	0.000
11. Yield (g)	10	9.523
	105	100.000

such a parent, and one cross involving a "deshi" and a "kabuli" parent. Practically every type of segregation was observed in the F_2, but there was no combination of a green seed coat on "kabuli" type seeds in the F_3. Thus, selection seems to have resulted in the elimination of poor combinations. Thus linkage between qualitative and quantitative characters can be profitably used to help selection in early generations.

Table 3

Mean values of clusters for different characters

Clusters	Cluster constitution	Characters										
		Spread (cm)	Height (cm)	Pod bearing length	Primary branch	Secondary branches	Pods/plant	Seeds/plant	Seed wt (g)	Flowering	Maturity	Yield (g)
I	JG-62 JG-6 × JG-2 JG-2 × JG-19	4.433	5.601	1.829	3.404	2.728	8.078	0.117	55.003	32.007	0.108	6.870
II	JG-6	—	—	—	—	—	—	—	—	—	—	—
III	JG-19 JG-62 × JG-19 JG-62 × JG-2	1.148	14.069	2.417	1.610	5.293	14.740	0.412	4.805	1.899	1.115	6.002
IV	JG-2 JG-19 × Pink-2 JG-2 × Pink-2	1.724	0.583	0.057	5.287	10.590	1.270	0.617	55.132	25.935	0.235	12.150
V	Pink-2 JG-62 × Pink-2 JG-6 × JG-19	8.436	2.096	5.343	1.426	1.115	3.223	0.192	6.233	1.514	0.028	1.896
VI	JG-62 × JG-6 JG-6 × Pink-2	0.121	0.004	0.178	4.219	3.583	0.048	0.040	12.936	12.397	0.329	2.812

It should be noted that while the parents were chosen for variation in seed characteristics, not in maturity, the analysis indicates that a 60% contribution to genetic divergence originated from seed weight while maturity made no contribution. When selection was done for yield, it could be considered responsible for different crosses in different clusters, since the parents had no selectional effect. Clusters IV and VI were more distant while clusters III and V were very close. It is important to note that while parent JG-2 was in cluster IV, one of its derivatives was in cluster VI and another in III. Thus, the effect of one parent alone may not have helped the particular cross to be perpetuated and only those genotypes which were close to the other parent could enter into one particular cluster.

The number of pods per plant and the yield came next to seed weight in their ability to cause divergence among the genotypes. It should be noted that JG-62 is a double podded parent, while the "kabuli" varieties are known for their poor yielding capacity (ROHEWAL *et al.* 1966). It was recommended that the yielding capacity of "deshi" varieties should be transferred in terms of their basal branching pattern to the "kabuli" genotypes. NAZIR (1964) also explored the possibility of transferring the double poddedness of *C. arietinum* to *C. kabulicum* for yield improvement. Maximum divergence was observed in JG-2 and JG-62×JG-6, while minimum divergence was observed for JG-62×Pink-2 and JG-6×JG-19. While Pink-2 has a "kabuli" background, JG-19 is a "kabuli" variety. Thus, it is possible to transfer characters in these genotypes for improving their genetic worth.

Maximum divergence in terms of character was found between clusters IV and V for yield, and crossing them together can help in exploiting hybrid vigour. ASAWA—ASAWA (1976) found sufficient genetic divergence in selected populations of red gram and were able to correlate it with the hybrid vigour reported by SHARMA *et al.* (1973). Most of the contribution to divergence was through height and parents divergent on this character did express hybrid vigour for this character in an independent study conducted by SHARMA *et al.* (1973).

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PRINCIPLES AND POSSIBILITIES OF EVALUATING DAIRY CATTLE POPULATIONS

The type of cattle which should be bred has always been, and in all probability will continue to be, a much debated subject. In proportion to the rapid improvement of technical conditions and the increasing prevalence of large-scale production patterns attention is turned more and more towards specialized producing types which, in turn, are expected to spread at an ever faster rate. Naturally, this does not mean that the trend of breeding aims will ever be uniform all over the world. It would not even be reasonable to try to attain this target, since under different conditions different types are required to obtain the optimum economic result, which may be fundamentally influenced by the farming, technical, economic, etc. conditions of the given country or regional unit. In any case "an organism is needed, which besides converting fodder into milk, butter, beef, etc. at the highest efficiency, requires the least possible human labour and can be adapted to up-to-date conditions of husbandry and mechanization" (HORN 1962). We feel that breeders who keep this basic principle in mind in the course of their work, are hardly likely to commit serious errors.

Looking at the question from this point of view, the data from herd books and milk recording, which are indispensable in high level livestock farming, are only suitable for establishing the effective value of a population with certain reservations. Namely, the production data hardly give enough information about the actual efficiency, e.g. the quantity of animal products produced per unit of nutrient consumed. Breeds, types and populations can only be reliably compared by means of an integrated evaluation of the stock. This means that the actual value of the different animal populations depends on the question: which type produces the largest quantity and highest quality of products suitable for human consumption, taking into consideration cow husbandry, calf production, heifer raising and fattening. Besides the usual milk recording data, a correct answer to this question can only be given after assessing the actual feed consumption of the cows, as well as the nutrient requirements for heifer raising and animal fattening.

The method of calculation is presented here using as models three populations characterized by different standard features. In the model calculation losses during raising, which are decisively influenced by the environment, were not taken into consideration. Table 1 contains the annual output of 100 cows and the starch equivalent required, as well as the calculated quantity of butter fat + milk protein and the live weight of slaughter cattle produced from the same starch equivalent.

Table 2 contains the 15 parameters to be determined experimentally, together with other fundamental data used for the calculations.

The model calculations clearly show how different the efficiency of production in the individual types can be.

If there is no possibility of determining the feed conversion experimentally, the index number used to determine the efficiency of milk production in the populations should take into consideration not only the absolute milk production (best expressed in kg butter fat + milk protein) but also the milk production relative to live weight, with a 50% weighting. According to the relevant literary data, the milk production relative to live weight is the most reliable

Table 1

The production of 100 cows and their offspring and the necessary starch equivalent

Model				Production kg			Necessary starch equiv. kg		
				Model			Model		
I	II	III		I	II	III	I	II	III
100	100	100	Milk fat + protein production	24.000	36.000	41.000	315.000	280.000	250.000
85	90	95	Preparation for lactation	—	—	—	78.795	68.040	51.300
20	20	20	Weight increase of cow	—	—	—	4.000	4.000	4.000
20	20	20	Raising of heifer	—	—	—	50.480	47.000	43.360
42	45	48	Live weight production of bulls (fattened)	21.840	21.600	21.120	78.624	80.100	80.688
23	25	27	Live weight production of heifers (fattened)	8.970	9.000	7.810	35.121	37.125	38.718
			Total live weight production of young animals	30.810	30.600	28.930	—	—	—
20	20	20	Weight of culled cows	11.700	10.800	10.000	—	—	—
			Whole slaughter weight production	42.510	41.400	38.900	—	—	—
			Total starch equiv. requirement				562.020	516.26	468.066

Possible production of milk fat + protein and slaughter weight from 100,000 kg strach equiv.

	Model					
	I		II		III	
			%			
Cows to be kept, No.	17.8	100	19.4	109.0	21.4	120.2
Possible prod. of milk-fat + protein, kg	4.270	100	6.973	163.3	8.759	205.1
Possible prod. of young animals weight, kg	5.482	100	5.927	108.1	6.181	112.8
Weight of culled cows	2.082	100	2.092	100.5	2.136	102.6
Weight of all animals for slaughter	7.564	100	8.019	106.0	8.317	110.0

Table 2

Basic data

	Model		
	I	II	III
Experimental data:			
1. Birth weight: heifers, kg	35	30	25
bulls, kg	40	35	30
2. Weight at first calving, kg	550	500	450
3. Feed required for 1 kg weight increase until first calving (starch equivalent), kg	4.9	5.0	5.1
4. Weight of mature cow, kg	650	600	550
5. Calves born to 100 cows from first recording to the end of the year, No.	65	70	75
6. Yearly av. FCM milk prod. per cow, kg	3500	4000	5000
7. Average milk fat, %	3.8	5.0	4.5
8. Average milk protein, %	3.2	4.0	3.7
9. Milk fat, kg	133	200	225
10. Milk protein, kg	112	160	185
11. Milk fat + protein, kg	245	360	410
12. St. eq. for one kg milk + maintenance, kg	0.9	0.7	0.5
13. St. eq. used for one kg bull weight from birth to slaughtering, kg	3.9	4.0	4.1
14. St. eq. used for one kg fattened heifer weight from birth to slaughtering, kg	4.3	4.5	4.7
15. Cows to be replaced by heifers, No.	20	20	20
Assumed data:			
16. Duration of dry period, day	60	60	60
17. Preparation of cows for lactation, kg	18	18	18
18. St. eq. for one kg growth rate of cow (without maintenance), kg	2	2	2
19. Optimal end weight of fattened bulls (80% of mature weight of cow), kg	520	480	440
20. Optimal end weight of fattened heifers (60% of mature weight of cow), kg	390	360	330
21. Weight of culled cow (90% of mature cow weight), kg	585	540	500
Calculated from previous data:			
22. No. of calves born from 100 cows per year	85	90	95
23. No. of bulls which can be fattened from 100 cows	42	45	48
24. No. of heifers which can be fattened from 100 cows	23	25	27
25. St. eq. necess. to prepare for lact., kg	972	756	540
26. St. eq. necess. for the growth of one mature cow, kg	200	200	200
27. St. eq. necess. to raise one heifer from birth to calving, kg	2524	2350	2168
28. St. eq. to fatten a bull from birth to end weight, kg	1872	1780	1681
29. St. eq. to fatten a heifer from birth to end weight, kg	1527	1485	1434

Table 3

Evaluation of populations according to the efficiency index for milk production

	Standard population	I. model population	II. model population
Milk production up to the end of the 5th year, kg	15,000	12,000	9,000
Average milk fat, %	4.0	5.0	3.8
Average milk protein, %	3.4	4.0	3.2
Milk production for one year of life, kg	3,000	2,400	1,800
Milk fat production for one year of life, kg	120	120	68
Milk protein production for one year of life, kg	102	96	58
Milk fat + protein production for one year of life, kg	222	216	126
Average live weight (measured after each calving), kg	500	550	600
Milk fat + protein production for one year of life per 100 kg live weight, kg	44	39	21
Efficiency index for milk production,* %	100.0	91.0	52.2

$$\text{* The efficiency index for milk production} = 100\times \frac{\text{Fat + protein production kg for one year of life}}{\text{Fat and protein production kg for one year of life in the standard population}} + \frac{\text{Fat + protein production kg for one year of life per 100 kg live weight}}{\text{Fat and protein production kg for one year of life per 100 kg live weight in the standard population}}$$

index of feed conversion in milk production (SUCHANEK 1963, DOHY 1970, DOHY—LUDROVSZKY 1965, ERNST *et al.* 1973, — MILLER—HOOVEN 1971, NAITO—TAKAHASHI *et al.* 1974, etc.).

On this basis we have worked out an "efficiency index of milk production" (HORN 1966) which takes into consideration the absolute production and that relative to the live weight on a 1 : 1 ratio, and expresses them with reference to a model cow or model population. This system, which considers both the absolute production and the efficiency of production, can also be used for the evaluation of populations. The course of the calculation on model populations is shown in Table 3.

For the cows belonging to this population the production results attained until the last day of the fifth year of life were considered and were distributed over one year. This system has the advantage of giving equal weight to the absolute production and that relative to the live weight, and also to early sexual maturity and reproductive properties. The method suggested undoubtedly has the deficiency of leaving out of consideration the production and proportion of animals culled before the fifth year of life. Further investigations and calculations are required to find out how the effect of the different ratios of culling before the fifth year can be properly expressed in the evaluation of the populations. It might seem to be reasonable to carry out the calculations by the same method on the basis of the amount of milk produced until the day of culling. However, in that case greater emphasis would be laid on the period of raising young animals than would be justified by its actual economic value.

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EFFECTS OF POPULATION DENSITIES AND ROW SPACINGS ON KENAF YIELDS AND ITS COMPONENTS IN THE KENANA AREA OF THE SUDAN

Kenaf (*Hibiscus cannabinus* L.) is an important cordage crop in many parts of the world. The bast fibres are used for the manufacture of twine, rope, bagging, rugs and other products. A greater number of plants per unit area has been the means of increasing yields of dry matter (Massey 1974).

In Georgia, North Carolina and Texas (White *et al.* 1970), narrow rows produced higher kenaf yields than wide rows. Williams (1966) reported that the highest stem yields were obtained from narrow rows. Killinger (1965) reported higher yields in 0.97 m than in 0.48 m rows and found that row width did not materially affect stem yield.

Crane *et al.* (1946) in Cuba obtained 3077, 2371 and 1866 kg of fibre per ha from plants grown in 0.2, 0.4 and 0.6 m rows, respectively. The average number of plants per square metre were 100.0, 49.5 and 33.3, respectively.

Several workers (Higgins—White 1970, Whiteley 1971, Williams 1966, Wilson *et al.* 1965 and Wilson—Joyner 1969) reported that increasing the kenaf plant population caused a reduction in the plant height and stem diameter. Wilson—Joyner (1969) found that plant spacing had no effect on plant height.

The objective of the current research was to evaluate the effects of row width and plant population and their interaction on kenaf dry ribbon yield and other plant characteristics. The results reported in this paper cover three crop seasons, i.e. 1966, 1967 and 1968.

For this experiment a 4 replicated split-plot design was used. Three row spacings, i.e. 0.2, 0.3 and 0.4 m, represented the main plots, and the three plant populations, i.e. 1,000,000, 500,000 and 250,000 plant per ha occupied the subplots. An attempt was made to establish these populations by accurate thinning to the appropriate spacing within the row, as shown in Table 1. All treatments received presowing watering and were irrigated immediately after sowing. From then onwards, watering continued fortnightly except when there was adequate rainfall.

In each year of the tests the experiment was sown on 15th May. Each treatment was harvested when an average of about 10 flowers per plant were in bloom. The stems were cut near ground level and tied into bundles. After recording the total fresh weight, the leaves, flower buds and flowers were removed to obtain the green stalk yield. These two operations were carried out immediately after cutting the stems. A hand fed decorticator was then used to separate the bark from the wood and to give the green ribbons. The fresh ribbon yields from the plots were dried in the sun for nearly a month and weighed for dry ribbon yield.

A representative sample of 10 plants was taken at random from each experimental plot for the determination of height, stem diameter 30 cm above the soil surface, dry ribbon yield per plant and ribbon percentage in the stem.

The plant stand percentage is the actual plant population at harvest as a percentage of the intended plant population.

The levels of significance for the components of variation (spacings, populations and spacings $\times$ populations) for individual years and their averages are shown in Table 2. Populations were an important cause of differences in dry ribbon yield per ha or per plant, total fresh yield, plant height and stem diameter, either in all years of the test or in some of them and also in the 3-year average; spacings were usually not important.

The effects of different spacings and populations tended to be independent of each other for all traits except plant stand percentage, as indicated by the preponderance of non-significant F-values obtained for the interaction of spacings $\times$ populations.

The plant stand percentage, shown in Table 3, consistently increased with decreasing plant population. Plant stand percentage decreased progressively from P_3 to P_1. The differences were significant ($P = 0.05$) only in the 1968 season and over the average of the three years of tests. A greater percentage of planted seeds produced plants as the rows narrowed and also as the population decreased. This was probably due to intrarow competition. In narrow rows (0.2 and 0.3 m spacings) and with high populations (P_1) the actual plant stand percentages at harvest, during the years, were generally smaller than those expected. This could have resulted

Table 1

Within-row spacings (m) used to obtain the desired plant population per ha

Population		Row spacing (m)		
Code	Plants/ha	0.20	0.30	0.40
P_1	1,000,000	0.05	0.03	0.02
P_2	500,000	0.10	0.07	0.05
P_3	250,000	0.20	0.13	0.10

Table 2

Significance of F-values from analysis of variance of kenaf row spacing — population trial

Year	Spacing	Population	Spacing×population
	Component of variation		
		Plant stand %	
1966	*	**	*
1967	N.S.	**	N.S.
1968	**	**	**
3-year average	**	**	**
		Plant height (m)	
1966	**	N.S.	N.S.
1967	N.S.	*	N.S.
1968	N.S.	N.S.	N.S.
3-year average	N.S.	**	N.S.
		Stem diameter (Vm)	
1966	N.S.	**	N.S.
1967	N.S.	**	N.S.
1968	N.S.	**	N.S.
3-year average	N.S.	**	N.S.
		Total fresh yield (kg/ha)	
1966	N.S.	*	N.S.
1967	N.S.	N.S.	N.S.
1968	N.S.	N.S.	N.S.
3-year average	N.S.	*	N.S.
		Dry ribbon yield per plant (g)	
1966	*	**	N.S.
1967	N.S.	**	N.S.
1968	N.S.	**	N.S.
3-year average	N.S.	**	N.S.
		Dry ribbon yield (kg/ha)	
1966	N.S.	**	N.S.
1967	N.S.	N.S.	N.S.
1968	N.S.	*	N.S.
3-year average	N.S.	N.S.	N.S.

N.S. Not significant. * Significant at the 5% level. ** Significant at the 1% level.

Table 3

*Influence of plant population and row width on the plant stand percentage at harvest time**

Row width (m)	Population	Year			Mean
		1966	1967	1968	
0.20	P_1	81.8 b	75.9 a	82.0 c	80.2 c
	P_2	99.9 a	92.6 a	100.0 a	97.5 ab
	P_3	100.0 a	100.0 a	100.0 a	100.0 a
0.30	P_1	80.5 b	56.4 a	85.0 c	74.0 c
	P_2	100.0 a	91.2 a	98.4 ab	96.5 ab
	P_3	100.0 a	100.0 a	100.0 a	100.0 a
0.40	P_1	61.4 c	55.4 a	54.6 d	57.1 d
	P_2	95.8 a	85.2 a	91.9 ab	91.0 b
	P_3	100.0 a	100.0 a	95.0 ab	98.3 a
		(±3.39)	(±4.40)	(±2.29)	(±2.14)
0.20		93.9 a	89.5 a	94.0 a	92.5 a
0.30		93.5 a	82.5 a	94.5 a	90.2 a
0.40		85.7 a	80.2 a	80.5 b	82.1 b
		(±2.28)	(±4.58)	(1.97)	(±1.84)
	P_1	74.6 b	62.6 c	73.9 b	70.4 b
	P_2	98.6 a	89.7 b	96.8 a	95.0 a
	P_3	100.0 a	100.0 a	98.3 a	99.4 a
		(±2.26)	(±2.94)	(±1.53)	(±1.43)

* Numbers followed by the same letter in a given column are not significantly different at the 0.05 level according to Duncan's multiple range test

from greater disturbance to the plants at thinning, infestation of damping-off disease immediately after emergence or heat canker occurring after thinning.

Due to the non-significance of the interaction for all characters studied with the exception of plant stand percentage, the average data for each of the population and spacing treatments are shown in Tables 4 and 5, respectively.

There was a general consistent trend for the stem diameter, plant height, dry ribbon yield per plant and total fresh yield per ha to decrease as the population increased in each year of the test and over the average of the years (Table 4).

According to the 1967 season trial and the 3-year average analysis, the plants of the P_3 population had the tallest height and were not significantly different from those of the P_2 population, but they significantly ($P = 0.05$) exceeded those of the P_1 population by more than 0.13 m (Table 4b). The plant height difference between P_1 and P_2 was not significant.

From the analysis of the 1966 season and from the 3-year average for the total fresh yield per ha, the yields from P_3 and P_2 were nearly the same and significantly ($P = 0.05$) out-yielded those obtained from P_1 (Table 4c).

Population effects on the dry yield per ha (Table 4d) were significant ($P = 0.05$) in the 1966 and 1968 seasons. In 1966, the dry ribbon yield tended to increase progressively with

Table 4

*Effect of plant population on kenaf dry ribbon yield and some other plant characteristics**

Plant population	Year 1966	1967	1968	Mean
	a: *Stem diameter* (mm)			
P_1	9.8 b	8.5 b	10.0 b	9.4 c
P_2	10.7 ab	9.5 ab	10.6 b	10.2 b
P_3	11.4 a	10.1 a	11.7 a	11.0 a
	(±0.32)	(±0.35)	(±0.32)	(±0.13)
	b: *Stem height* (m)			
P_1	2.42 a	2.44 b	2.48 a	2.45 b
P_2	2.47 a	2.59 ab	2.46 a	2.50 ab
P_3	2.56 a	2.61 a	2.56 a	2.58 a
	(±0.05)	(±0.05)	(±0.05)	(±0.04)
	c: *Total fresh yield* (kg/ha)			
P_1	41674 b	50028 a	47005 a	46362 b
P_2	48290 ab	50789 a	52455 a	50504 ab
P_3	52931 a	52336 a	49337 a	51527 a
	(±2546)	(±1342)	(±2832)	(±1662)
	d: *Dry ribbon yield* (kg/ha)			
P_1	4227 b	5574 a	4510 b	4770 a
P_2	4891 ab	5443 a	5112 a	5149 a
P_3	5195 a	5374 a	4629 b	5066 a
	(±224)	(±138)	(±145)	(±83)
	e: *Dry ribbon yield per plant* (g)			
P_1	6.07 b	9.68 c	6.48 c	7.03 c
P_2	9.91 ab	12.38 b	10.70 b	10.85 b
P_3	18.76 a	21.08 a	17.90 a	18.93 a
	(±0.75)	(±0.75)	(±0.53)	(±0.34)

* Numbers followed by the same letter in a given column are not significantly different at the 0.05 level according to Duncan's multiple range test

Table 5

*Effect of row width on kenaf dry ribbon yield and some other plant characteristics**

Row width (m)	Year			Mean
	1966	1967	1968	
	a: *Stem diameter* (mm)			
0.20	10.7 a	9.6 a	10.6 a	10.3 a
0.30	10.2 a	9.3 a	10.9 a	10.3 a
0.40	10.9 a	9.2 a	10.8 a	10.2 a
	(±0.28)	(±0.35)	(±0.46)	(±0.29)
	b: *Stem height* (m)			
0.20	2.52 a	2.64 a	2.52 a	2.57 a
0.30	2.39 b.	2.52 a	2.48 a	2.47 a
0.40	2.55 a	2.48 a	2.50 a	2.51 a
	(±0.02)	(±0.05)	(±0.02)	(±0.03)
	c: *Total fresh yield* (kg/ha)			
0.20	46648 a	50337 a	47291 a	48092 a
0.30	42792 a	50337 a	45958 a	46362 a
0.40	53431 a	52479 a	55525 a	53812 a
	(±3284)	(±1064)	(±5641)	(±2594)
	d: *Dry ribbon yield* (kg/ha)			
0.20	4731 a	5498 a	4543 a	5224 a
0.30	4486 a	5379 a	4529 a	4798 a
0.40	5129 a	5514 a	5093 a	5245 a
	(±156)	(±124)	(±150)	(±29)
	e: *Dry ribbon yield per plant* (g)			
0.20	10.52 b	13.85 a	10.24 a	11.31 a
0.30	10.86 ab	14.12 a	10.61 a	11.62 a
0.40	13.37 a	15.17 a	14.23 a	13.88 a
	(±0.79)	(±1.13)	(±1.14)	(±0.74)

* Numbers followed by the same letter in a given column are not significantly different at the 0.05 level according to Duncan's multiple range test

decreasing plant population. In 1968, the highest yield was given by the intermediate population (P_2) which significantly ($P = 0.05$) out-yielded both P_1 and P_3. No relationship of population to dry ribbon yield was observed in 1967, but with increased population the increases in dry ribbon yield were of low magnitude. From the average of 3 years, it was noticed that differences among the three populations were not significant, but both P_2 and P_3 out-yielded P_1 by 7%.

An increase in plant density decreased the stem diameter in all years (Table 4a). Thus larger stems compensated for the lower number of plants per unit area and generally resulted in similar yields for the densities tested. This was confirmed by MASSEY (1973) in Georgia.

According to each annual test and the average of years, the differences in dry ribbon yield per ha between the three different row spacings were not significant. But in general the 0.4 m row spacing gave an increase in yield of low magnitude compared to those obtained from 0.3 and 0.2 m row spacings. Also, the yields of the 0.3 m row spacing were always lower than those of the 0.2 m row spacing in all years of the test.

The differences in stem diameter and total fresh yield among the row spacings were not significant in any of the years or over the average of the three years. But the trend for total fresh yield showed that the highest yields were obtained from the 0.4 m row spacing.

In general row spacing had no effect on plant height except in 1966, when the plants of the 0.3 m spacing were significantly ($P = 0.05$) shorter than those developed at 0.2 and 0.4 m row spacings (Table 5b). For the other years and the 3-year average, the average heights of the plants in the 0.2 m row spacing were much taller than those in the 0.3 and 0.4 m row spacings.

Dry ribbon yield per plant was maximized at a row spacing of 0.4 m. Both 0.2 and 0.3 m row spacings yielded plants which had a similar dry ribbon yield, but their yields were lower than those obtained from the 0.4 m row spacing in each year of the test and than the average.

The more salient results of correlation analysis of variables are presented in Table 6. Plant stand percentage and total fresh yield showed significant positive correlations with dry ribbon yield, while the stem diameter gave a positive low correlation. On the other hand, HIGGINS—WHITE (1970) found that yield was not influenced by plant population. Dry ribbon yield per plant showed a positive but non-significant correlation with dry ribbon yield per ha and plant stand percentage. Dry ribbon yield per plant and plant stand percentage gave significant positive correlations with stem diameter.

The associations of plant height with dry ribbon yield per ha, dry ribbon yield per plant, plant stand percentage and stem diameter were positive but non-significant. The work of

Table 6

Correlation coefficients between dry ribbon yield and five other yield components

Variable	Dry ribbon yield (kg/ha)	Dry ribbon yield per plant (g)	Plant stand percentage	Stem diameter (mm)	Plant height (m)
Dry ribbon yield per plant (g)	0.60				
Plant stand percentage	0.78**	0.65			
Stem diameter (mm)	0.17	0.70*	0.67*		
Plant height (m)	0.24	0.37	0.34	0.55	
Total fresh yield (kg/ha)	0.99**	0.66*	0.24	0.49	0.19

* Significant at the 0.05 level of probability
** Significant at the 0.01 level of probability

Higgins—White (1970) and Williams (1966) gave a positive significant correlation between stem diameter and plant height. Stem diameter decreased with an increase in plant population. Williams (1966) reported a highly significant negative correlation between plant population and plant height ($r = 0.51$) and between plant population and stem diameter ($4 = 0.75$). Total fresh yield was significantly and positively associated with dry ribbon yield per plant. Plant stand percentage, stem diameter and plant height were positively, but non-significantly correlated with total fresh yield.

The lack of effect of population differences on the dry ribbon yield suggests that medium rather than high or low populations should be used to avoid gaps in the stands and to provide more competition against weeds. Offsetting the advantages of high populations are the extra seed required and the small thin plants developed which tend to lodge badly near the end of the season. Many of these small thin plants are lost if harvesting is delayed or because they are not decorticated mechanically, because the blades or knives of the hand-fed decorticator are adjusted to a certain stem diameter. Also the results indicated that under the conditions of this experiment, narrow rows gave no yield advantage over wide rows even with different population densities. This might be due to the high losses in plant population which reached on average, 20%, 25% and 40% for 0.2, 0.3 and 0.4 m row spacings, respectively, especially for the P_1 population density (Table 3). Among the three row spacings, the highest loss in plant population was obtained at 0.4 m row spacing. Nevertheless, the maximum dry ribbon yield was produced at 0.4 m row spacing. It appears that high dry ribbon yields might be expected by increasing the density of population (P_2) with wide row spacings or by narrowing the distance between the rows, coupled with low to medium densities. The same idea was reported by Williams (1966).

For kenaf production in the Kenana area the two lowest population densities (500,000 and 250,000 plant/ha) are recommended with narrow row spacings, such as 0.2 or 0.3 m.

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DATA ON THE TECHNOLOGICAL TOLERANCE OF CATTLE OF VARIOUS GENOTYPES

The decreasing number of people employed in livestock farming, and the demand for increased profitability render it necessary to develop livestock farming methods in which the use of machines is the decisive factor, while those individualities of the animals which differ from the stock average can hardly be taken into consideration, if at all. Technical progress, as a given environmental factor, requires the keeping of populations whose individuals give uniform, identical responses to large-scale husbandry.

In specialized, large-scale livestock farms the animals are exposed, with hardly any transitional phase, to nearly as great a change as may have been experienced in the early stages of domestication. Consequently, the balance between the biological requirements of the animals and the changed environment has been upset. This unbalance is due to the fact that the demands of the animals have virtually been left out of consideration, and the selection of populations tolerant to large-scale husbandry has not been accompanied by the establishment of up-to-date livestock stations. In fact, due to a lack of proper knowledge, this was quite impossible up till now. Today, when the technology of large-scale livestock farming, instead of becoming more simple, necessarily tends towards the utilization of more and more complex technical means, the establishment of a technico-biological equilibrium, i.e. the restoration of a balance between the animal and its environment, is an urgent task.

Behaviour as a signalizing system, as an integrated life phenomenon, shows whether the environment is healthy for the animals. The life phenomena expressed by the behaviour of the animals are of great importance, because physiological tests, which likewise indicate the general health conditions of the animal, are very difficult to perform under farm conditions. Conclusions on the general health conditions of animals can also be drawn from the changes occurring in the quantity and quality of production, but such indications do not fully serve the purpose, as they come rather late, sometimes too late.

It is a well-known fact that the fulfilment of production demands involves not only technical, but also biological requirements. In cattle husbandry the biological requirements must be taken into consideration to a much greater extent than in poultry or pig farming. Pigs and poultry accommodate themselves to the new technology in a shorter time than cattle do, or rather such types are easier to select, owing to the quicker reproduction of the species. In large-scale husbandry it is in cattle that the greatest number of problems arise in creating a balance between the demands of the animals and the technical changes. It is thus in this field that the largest amount of information is required before deciding which production factors call for a technical solution and which should be approached from a biological point of view. The environmental conditions of production should be continuously co-ordinated with the biological requirements of the animals, that is, the stimulus given by the changed environment must not be strong enough to hinder the full display of the genetic capacity. In large-scale husbandry the concentration of the livestock and the utilization of technical facilities may modify the behaviour pattern of the animals compared to the behaviour of those kept under natural conditions, since in the closed technological systems the animals cannot find the same comfort as is offered by the natural environment. Thus, the extent of accommodation must be determined through the behaviour, because substantial changes in the way of life, reactiveness and behaviour of the animals may cause not only a reduction in output but also other losses.

According to the results of experiments and the experience gained so far, the accommodation of cattle is in most cases a slow process taking several generations. High productivity seems to be a more readily developed character than adaptation. Under the present circumstances the development or improvement of a technological tolerance in the different populations is thus extremely important.

The technological tolerance of the animal can be characterized by many reactions given to so-called external stimuli. The technological tolerance is expressed by responses to human interference, housing and feeding conditions, technical procedures, environmental pollution, relations with other animals, in a word: by behaviour.

To determine the technological tolerance of cattle investigations were set up with breeds reared in Hungary, aimed at acquiring a knowledge of the technological tolerance of the different breeds, and at finding some means of improving it.

This paper presents data on some features of animal behaviour which give information about their technological tolerance. These are:

— behaviour during milking,
— behaviour during work done in the cattle-shed,
— attitude towards man,
— accommodation to the new environment,
— finding the right place when driven into a bound system cattle-shed,
— distance kept between animals reared in groups.

The experiments were carried out in a number of farms with cows of different genotype (of various breed and crossing) kept in bound and fre- pen systems. Behaviour during milking and when work was done in the cattle-shed, as well as the attitude towards man were evaluated by a system of points. In evaluating the experimental results the following model was generally used:

$$X_{ijk} = \mu + a_i + b_j + e_{ijk}.$$

In the model X_{ijk} = the behaviour feature examined for k observations, i animals and j populations; μ = mean value; a_i = the effect of i animals; b_i = the effect of j populations; e_{ijk} = chance error. The behaviour of cows of various genotype was studied during milking, during work done in the cow-shed and when an outsider approached. The reactions were evaluated on the points system used in etological tests to determine qualitative behaviour patterns. The categories for behaviour during milking were: very calm = 1 point; calm, moving while milked = 2 points; restless, ducks, lifts its leg = 3 points; changes place during preparation and milking and may kick = 4 points. Categories for behaviour during work done in the cattle-shed: lies and ruminates = 1 point; lies, sometimes stands up, and periodically ruminates = 2 points; mostly stands, sometimes lies down, ruminates standing = 3 points; stands and hardly ruminates if at all = 4 points.

Behaviour when somebody approaches: calm, does not duck its head when touched by hand = 1 point; restless when someone approaches, but allows itself to be touched = 2 points; restless, makes butting movements = 3 points; restless, jerks up its head, trembles when touched by hand = 4 points.

Table 1 shows the behaviour of cows in first calf of various genotype kept bound. There were significant differences in behaviour during milking and when someone approached between the populations kept in the same farm. The calmest behaviour was shown during milking by the Hungarian spotted cows, and during work done in the cattle-shed and at the approach of man by the Danish red F_1. The correlation between the milk yield and the three characteristics of behaviour examined was very low. Exact data are not presented here.

Table 2 gives an account of the fact that brown dairy cows in two farms with a nearly identical bound husbandry system showed similar behaviour during milking and other work done in the cow-shed, as well as at the approach of man. There was no significant difference between the behaviour patterns examined in the two farms.

The behaviour of cows of various genotype kept in a free-pen system is seen in Table 3. As regards the behaviour of cows during milking no difference was found either between the farms or between the populations, but there was some difference in resting and ruminating

Table 1

Behaviour of cows in first calf of various genotypes kept in a bound system on the same farm

Breed	Behaviour during milking, in points				Behaviour during shed work, in points				Behaviour at the approach of man, in points			
	Number of animals	$\bar{x}$	$\pm s$	F-value	Number of animals	$\bar{x}$	$\pm s$	F-value	Number of animals	$\bar{x}$	$\pm s$	F-value
Hungarian spotted	16	1.38	0.69		16	2.44	0.90		16	1.58	0.75	
Dairy Hungarian spotted	19	2.22	0.44	14.97	19	1.55	0.81	14.37	19	1.44	0.52	2.98
Danish red F_1	21	1.47	0.60	$P < 0.1\%$	21	1.52	0.51	$P < 0.1\%$	21	1.00	0	
Holstein Friesian F_1	18	2.10	0.76	$P < 0.1\%$	18	1.61	0.50	$P < 0.1\%$	18	1.55	0.51	$P < 5\%$

Table 2

Behaviour of Hungarian brown dairy cows in a bound system on two farms

Farm	Behaviour during milking, in points				Behaviour during shed work, in points				Behaviour at the approach of man, in points			
	Number of animals	$\bar{x}$	$\pm s$	F-value	Number of animals	$\bar{x}$	$\pm s$	F-value	Number of animals	$\bar{x}$	$\pm s$	F-value
A-farm (Nyírmada)	36	1.63	0.53	0.91	36	2.56	0.96	1.42	36	1.65	0.72	1.16
B-farm (Kemecse)	36	1.52	0.48	$P > 5\%$	36	2.81	1.02	$P > 5\%$	36	1.73	0.81	$P > 5\%$

Table 3

Behaviour of cows of various genotypes in a free-pen system

Breed	Behaviour during milking, in points				
	Number of animals	x	±s	F-value between genotypes	F-value between farms
Hungarian spotted	111	1.26	0.37	2.42	3.21
Dutch black and white	160	1.00	—	P > 5%	P > 5%
Holstein Friesian	48	1.00	—		

Breed	Behaviour during shed work, in points				
	Number of animals	$\bar{x}$	±s	F-value between genotypes	F-value between farms
Hungarian spotted	100	2.40	0.49	14.15	2.81
Dutch black and white	160	2.95	1.11	P < 5%	P > 5%
Holstein Friesian	48	2.56	0.58		

Breed	Behaviour at the approach of man, in points				
	Number of animals	$\bar{x}$	±s	F-value between genotypes	F-value between farms
Hungarian spotted	100	1.97	0.38	27.3	19.6
Dutch black and white	160	1.55	0.33	P < 5%	P < 5%
Holstein Friesian	48	2.06	0.34		

while work was done in the cattle-shed. The highest degree of tolerance was shown by the Hungarian spotted cows. The differences between the farms were not significant. In the behaviour at the approach of man the differences both between the genotypes and the farms were significant, which suggests that it is not exclusively on the genotype that the reaction depends. The extent of accommodation is also a function of the treatment the animals receive in the farm.

Table 4 shows the correlation between milk yield and the behaviour of cows during milking and other work done in the cow-shed, and at the approach of man.

The correlations between the three behaviour patterns examined and the milk yield were very low or hardly demonstrable, so the regression equations are not presented here. We examined the effect of a new technological process or a new husbandry system on the behaviour of cows, and the time required for them to accommodate to the new technology. Within this framework we studied the behaviour of Hungarian spotted, dairy Hungarian spotted, and Dutch black and white cows in first calf transferred from a bound system in littered sheds to a free-pen system in litterless sheds. At the same time, we tried to determine the order followed by cows kept in groups of 24 when entering the milking box in the morning and evening. Table 5 shows the time spent in resting and moving about on the 1st, 5th and 14th day by cows placed in a new technological system. According to the data in the table the Hungarian spotted cows

Table 4

Relationship between milk production and behaviour

Relationships	Correlation		
	Hungarian spotted	Dutch black and white	Holstein Friesian
Behaviour during milking — milk production	+0.11	—	—
Behaviour during shed work — milk production	+0.10	−0.18	−0.11
Behaviour at the approach of man — milk production	+0.25	−0.01	−0.03

Table 5

Trend of the daily periods of resting and moving under changed technological conditions (Number of cows per group = 24) (transfer from a bound, littered to a free, litterless system)

Designation		Breeds examined		
		Hungarian spotted	Dairy Hungarian spotted (25% Jersey gene)	Dutch black and white
Time of lying down as a percentage of the daily 24 hours				
1st day	$\bar{x}$	27.62	34.51	33.28
	$\pm s$	10.21	8.63	8.16
5th day	$\bar{x}$	36.16	34.11	33.97
	$\pm s$	9.65	8.83	9.11
14th day	$\bar{x}$	47.56	45.28	46.71
	$\pm s$	11.32	10.83	11.16
Time of moving as a percentage of the daily 24 hours				
1st day	$\bar{x}$	10.66	8.23	9.18
	$\pm s$	2.97	2.17	2.81
5th day	$\bar{x}$	3.12	4.26	4.03
	$\pm s$	0.76	0.98	0.91
14th day	$\bar{x}$	1.32	1.48	1.16
	$\pm s$	0.21	0.37	0.31

spent 27%, the dairy Hungarian spotted cows 34% and the Dutch black and white cows 33% of the first day lying down. The characteristic daily values indicating lying down were observed on the 14th day after transfer to the new system in all three populations.

According to the data of Table 6, the Hungarian spotted, Hungarian dairy spotted and Dutch black and white cows spent 57, 70 and 82% of the feeding time characteristic of the population in feeding on the first day, and 88, 85 and 82% of this period on the 5th day. On the 14th day feeding took up 17—19% of the daily 24 hours; this is the time characteristic of large-scale husbandry. On the 1st and 5th day the time spent in rumination remained below the charac-

Table 6

Trend of the daily of feeding and ruminating under changed technological conditions (Number of cows per group = 24) (transfer from a bound, littered to a free, litterless system)

Designation		Breeds examined		
		Hungarian spotted	Dairy Hungarian spotted (25% Jersey gene)	Dutch black and white
Time of feeding as a % of the daily 24 hours				
1st day	$\bar{x}$	10.24	12.37	14.86
	$\pm s$	3.03	2.97	3.27
2nd day	$\bar{x}$	15.93	15.16	14.85
	$\pm s$	3.51	3.02	3.09
14th 6ay	$\bar{x}$	18.02	17.81	18.16
	$\pm s$	4.36	4.01	4.05
Time of rumination as a % of the daily 24 hours				
1st day	$\bar{x}$	20.41	17.85	19.07
	$\pm s$	5.13	4.29	4.81
5th day	$\bar{x}$	21.63	18.12	20.03
	$\pm s$	5.02	4.31	4.43
14th day	$\bar{x}$	27.19	25.70	29.78
	$\pm s$	5.47	6.18	6.89

Table 7

Order of entering the milking box

Designation	Breeds examined		
	Hungarian spotted	Dairy Hungarian spotted (25% Jersey)	Dutch black and white
1st day, %			
— in the same order	—	—	—
— with a difference of one place	—	—	6.6
— with a difference of two places	33.0	29.7	19.8
5th day, %			
— in the same order	3.3	6.6	9.9
— with a difference of one place	13.2	16.5	23.1
— with a difference of two places	29.7	23.1	29.7
14th day, %			
— in the same order	13.2	16.5	19.8
— with a difference of one place	24	23.1	29.7
— with a difference of two places	16.5	19.8	19.8

teristic value. On the 14th day Hungarian spotted cows spent 27, the dairy cows 25, and the black and white cows 29% of the day ruminating.

In Table 7 we can see what percentage of the cows in the group of 24 followed the morning order of milking, or deviated from it by one or two places, on entering the milking box in the evening. On the first day none of the Hungarian spotted cows and dairy Hungarian spotted cows, and only one of the black and white cows kept the same order of succession in the evening as in the morning when entering the milking box (3.3). On the evening of the 5th day 3.3% of the Hungarian spotted, 6.6% of the dairy Hungarian spotted, and 9.9% of the black and white cows entered the milking box in the same order of succession as in the morning. On the

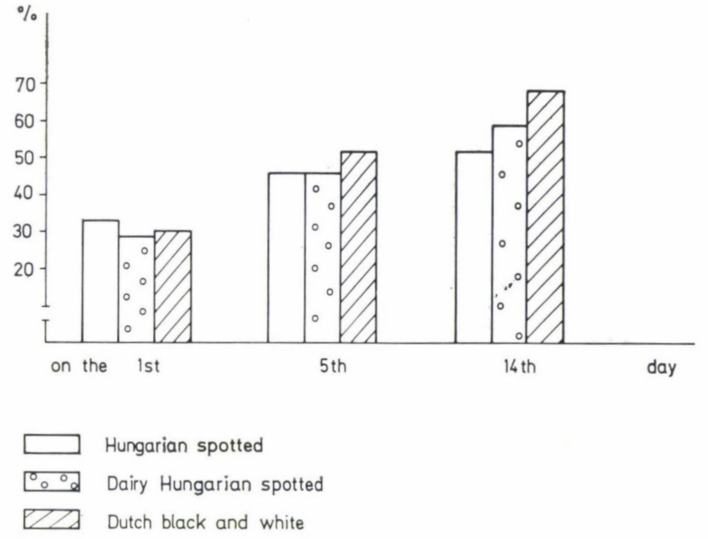

Fig. 1. Cows of various genotype entering the milking box in the same order of succession

14th day the differences between the populations decreased. According to Fig. 1, 52.8% of the Hungarian spotted, 99.4% of the dairy Hungarian spotted and 69.3% of the black and white cows followed the same order in the evening (or missed it by one or two places) as in the morning on entering the milking box. Accordingly, differences between the populations are not significant.

On examining the correlations between the milking order, and the live weight, the milk yield, and the order of boxes in the shed, we found that while each of the examined indices was in positive correlation with the order in which the cows entered the milking box, the correlations were not significant. The closest correlation was shown with the order of the boxes they occupied in the shed on the 14th day. Our observations suggest (we did not calculate the value of dominance) that this order corresponded to the order of dominance in the population.

It is a well-known fact that cows kept in a bound system do not always return to their boxes when driven in from the stock-yard. This hinders the work in the stable, therefor, ein some large-scale dairy farms the cows are not allowed out to the stock-yard. As numerical data were not available we examined the ability of cows to find their boxes. We attempted to determine the percentage of cows able to find their boxes and the proportion of errors for varying numbers of boxes in a row. The observations were made on 12 successive days.

Table 8

Relationship between the order of entering the milking box, and live weight, milk production and place occupied in the shed

Relationships	Correlation		
	1st day	5th day	14th day
Live weight — order of entering the milking box	0.38	0.26	0.28
Milk production — order of entering the milking box	0.12	0.19	0.17
Place occupied in the shed — order of entering the milking box	0.17	0.27	0.46

The place occupied in the shed was related to the passage leading to the milking box

Table 9

Cows finding their places in a bound system of husbandry

Population	Number of cows per group (n)	Cows finding their boxes per group				
		$\bar{x}$	$\pm s$	F-value		
				between populations	between group sizes	between farms
Hungarian spotted	24	6.43	2.162			
Hungarian spotted	40	8.31	2.86			
Hungarian spotted	25	16.91	1.97			
Dairy Hungarian brown	48	6.25	1.91	$P > 5\%$	$P < 5\%$	$P < 5\%$
Dutch black and white	25	1.35	0.42			
Dutch black and white	24	4.18	1.47			

The data obtained during the investigations are summarized in Table 9. The ability of cows to find their boxes depended primarily on the size of the group, secondly on the way they were treated in the respective farms, and finally on the breed. The correlations between the percentage of cows finding their boxes, and the size of the group and the difference in treatment between the farms are significant.

The data presented in Fig. 2 also show the influence of the treatment the animals receive on their ability to find their places. With approximately the same group size the difference in treatment between the farms was greater than the difference between the genotypes (breeds). Where the cowman was not interested in promting the development of a reflex of this kind, cows kept in small groups (of 25) were less capable of finding their boxes than those kept in large groups. Further, the technological tolerance is expressed by the extent to which the animals put up with the close vicinity of other cows. Cattle belong to the type of animals which keep a certain distance from each other, and have retained this behaviour throughout the process of domestication. It is known that in animals of this type a social stress develops if they have not enough space. This is manifested in threatening behaviour. In the course of earlier investigations, we demonstrated that the frequency of threatening gestures is closely connected with the space available per animal. Further, we have noticed that the closer two animals are to each other in the hierarchy, the larger the personal space, the distance between them is.

As we had no numerical data at our disposal, we carried out investigations on cows kept in groups, partly to find out at what point cows of a lower order would stop and turn away from the one at the top of the hierarchy (what distance they would keep), and partly to obtain an answer to the question of whether there is any difference between the genotypes as regards this feature of behaviour.

The examinations — in which the place of each animal in the hierarchy was first determined — were performed with Hungarian spotted and Holstein Friesian groups. Data indicating the size of the personal space are contained in Table 10. The data in the table reveal that the size of the personal space varies with the place occupied in the hierarchy. There is no significant difference in this respect between the two breeds examined. According to the data of Fig. 3,

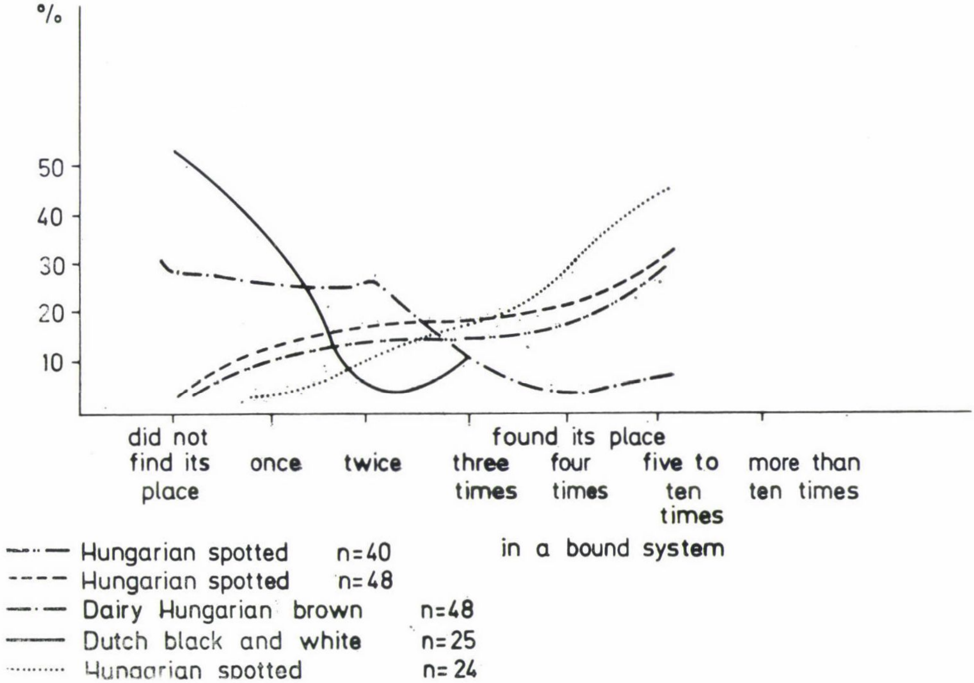

Fig. 2. Distribution of cows finding their places in a bound system of husbandry

the correlation between the hierarchical status and the personal space is very close (Hungarian spotted: $r = 0.96$; Holstein Friesian: $r = 0.94$).

The personal space can be characterized by linear regression. According to the determinative coefficients, the size of the personal space in Hungarian spotted cattle is 92% determined by the place occupied in the hierarchy and 8% by other factors, while the corresponding values for Holstein Friesian cattle are 88% and 12%, respectively.

Behaviour giving information on the technological tolerance of animals as a form of adaptation is extremely important in the development of large-scale technologies if it is related to production. We do not know as yet what extent of information fixing is involved in the concentration of the stock and the utilization of various technologies, nor whether or not they induce the phases of storage. So far investigations which might help in choosing the right technologies or breeds by assessing the present conditions have not been carried out. According to our

Table 10

Distance kept from the cow at the top of the hierarchy

	Distance kept from the cow first in the order of dominance by those occupying the				
	2nd	3rd	4th	6th	10th
	place in the group				
Hungarian spotted					
Distance of stopping (m)					
$\bar{x}$	2.8	2.5	2.1	1.5	1.1
$\pm s$	0.75	0.57	0.49	0.41	0.30
Holstein Friesian					
Distance of stopping (m)					
$\bar{x}$	2.6	2.5	2.0	1.6	1.3
$\pm a$	0.68	0.63	0.31	0.49	0.42

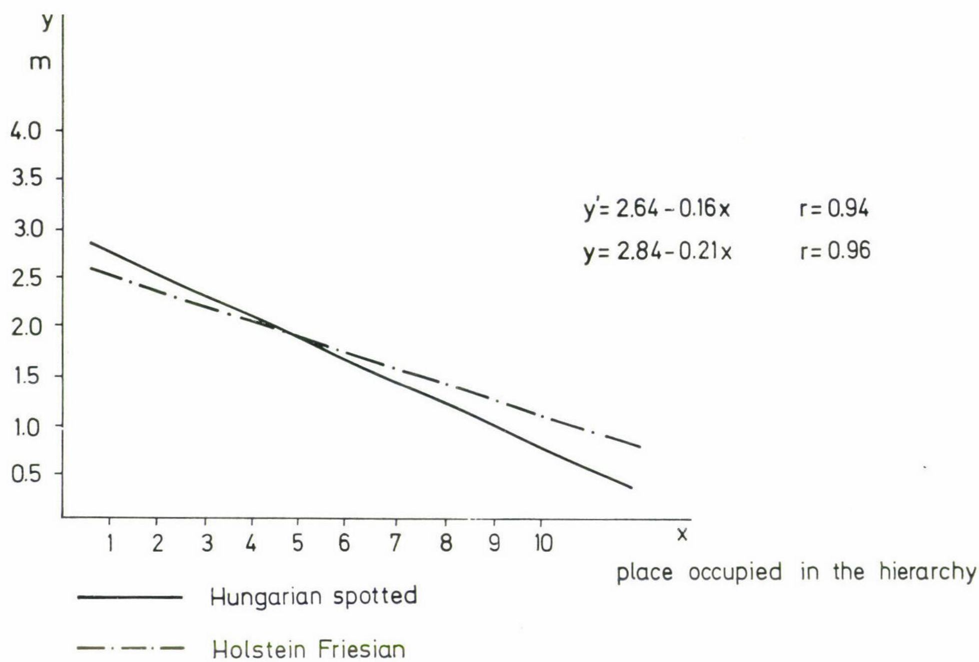

Fig. 3. Relationship between the social hierarchy and the personal space of the cows

experiments, there is no substantial difference between the genotypes examined as regards behavioural reactions which suggest technological tolerance. It was only in the bound system that small but significant differences were observed in the behaviour of animals during milking and work in the shed, and in response to the approach of man. In the milking box the cows showed identical behaviour during milking. In the behaviour displayed by the cows while work was done in the sheds, which had to be taken into consideration when studying rumination, differences were found between the genotypes. However, according to the method used by us, there seemed to be little connection with production. Thus, other factors must be found to account for the 10—20% decrease in yield, which is attributed to the absence of technological tolerance. As to the attitude of the cows towards man, the differences are again greater between the farms than between the genotypes. There is thus no evidence of some breeds or genotypes being easier to treat under large-scale husbandry conditions than others.

As regards accommodation to the new technology, there was no substantial difference between the three populations of different genotypes studied. Investigations on other genotypes might be expected to lead to similar results. The order of entering the milking box has a bearing on milk production (Czakó—Illés 1962). In the populations examined, even in smaller groups, only 50—60% of the cows entered the milking box in the same order or with a difference of one or two places. The aim is to milk at least 95% of the cows in a definite order of succession. The literary data suggest that cattle are more difficult to train to certain technological processes than other farm animals (Brantas 1968, Andreae 1971). Studies in this field would greatly help in acquiring a knowledge of the degree of adaptation of the individual genotypes.

An attempt was made to determine the orientation ability of cows in preliminary experiments in which we studied to what extent cows kept in a bound system were able to find their place. This ability is probably an acquired behaviour pattern. Driving the animals out and tying them up, as permanent external stimuli, seem to bring about the fixation of information only with the help of human intervention, since besides the size of the group an essential role is also played by the treatment the animals receive in the farm. Animals with no demand for physical contact keep a so-called individual distance (personal space) from one another (Heidiger 1955). In the course of our investigations we found that the size of this distance within the group depended on the place occupied in the social hierarchy. As the hierarchical distance between two individuals increases so the physical distance, which on being trespassed upon induces threatening behaviour, or causes the trespasser to stop and turn away, decreases. In the course of domestication human intervention has modified the distance-keeping mechanism of the cattle. In spite of this they demand more space than would be necessary for their life processes on the basis of their body mass. This additional space is the personal space. In determining the area required per animal, once the social hierarchy has been established, the personal space of the animals following each other in the hierarchy must also be taken into consideration, as well as the body volume. Further experiments are required to determine the minimum area demanded by an animal. As regards personal space no difference was found between the two breeds examined. The role played in production by the factors of technological tolerance examined so far is not quite clear. It may be stated, however, that characteristic differences in this respect do not exist between the genotypes, that is, no populations are yet available which show a higher tolerance to large-scale husbandry systems.

It should be noted, however, that individual differences in all parameters are much greater within than between the populations. As regards technological tolerance emphasis is still laid on the individuals rather than on the genotypes (populations), and the question of what to do with those animals which show the least tolerance may cause a problem.

*

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CONTRIBUTION TO THE PHARMACOGNOSY OF VISCUM ALBUM L.

I. Effect of host trees on choline content

The mistletoe (*Viscum album* L.) is one of the earliest recorded drug plants. The actual therapeutic effect of the drug, as it is known today, was recognized at the beginning of this century. Attention was called to its medical importance by the researches of Gaultier, a French pharmacologist, who was the first to observe in 1907 the hypotensive effect of an aqueous extract of the plant (AUSTER—SCHÄFER 1960, BERGER 1950, MADAUS 1938). The investigations were initially aimed at clarifying the pharmacology of the substance responsible for the decrease in blood pressure. This question has been dealt with in a number of papers by KOCHMANN (1931), JARISCH (1938, 1939, 1941), JARISCH—RICHTER (1940), ENDERS (1940), ENDERS *et al.* (1941), FEUCHTINGER (1940), JANSSEN *et al.* (1940) among others. Besides the hypotensive effect, which is easy to compensate with atropine, other effects of both the drug extract and of various mistletoe preparations, produced for the purpose of studying the action of the drug, were observed after intravenous injection, e.g. cardiotoxic symptoms similar to those induced by digitalis (JARISCH 1938, 1939, KOCHMANN 1931), and recently tissue necrosis and tumour inhibition (JARISCH 1939, 1941). According to our present knowledge choline is one of the substances responsible for the decrease in blood pressure.

The cardiotoxic effect is attributed to the viscotoxin, while the tissue necrosis is considered to be caused by toxic peptides of similar chemical composition (SANDBERG 1970, WINTERFELD 1952, WINTERFELD—DÖRLE 1942, WINTERFELD—HEUKEN 1960, WINTERFELD—KRONENTEAHLER 1942).

It is known that *Viscum album* L. is a parasitic plant, not particular about its host plant; it lives on many coniferous and nearly all deciduous trees. It prefers those known in forestry as "soft-wood", as the suckers can easily penetrate the wood, but it can also be found on many so-called "hard-wood" trees, e.g. robinia, walnut, fruit-trees, but very seldom on plum, oak and beech trees and never on hornbeam and black pine (HEGI 1957, AUSTER—SCHÄFER 1960, HOPPE 1958).

In recent decades it has become a widely accepted opinion that, beyond the site conditions and other environmental factors, the composition and consequently the effect of the mistletoe is also influenced by the host tree.

In order to study the hypotensive and cardiotoxic effects of the plant PORA *et al.* (1957) first performed experiments with animals and then administered extracts of drugs obtained from 12 different host trees to patients suffering from essential high blood pressure. According to their quantitative evaluation, the hypotensive effect of the drug is greatly influenced by the host plant.

At the beginning of the century, Tubeuf pointed out that the high morphological diversity was due to differences in the nutrients sucked out of the host plants. Hecker attributed an important role to the host plant in the diverse therapeutic effect of the mistletoe. In our opinion, among the factors influencing the biosynthesis of the plant components, apart from ecological factors, the nutrient conditions may play a decisive role, since as a parasitic plant the possibility of nutrient absorption in *Viscum album* is of a different nature. We thought it probable that the dissolved nutrients were more easily absorbed from the "soft-wood" than from the "hard-wood", the latter having thick-walled tracheae, more or less blocked parenchyma and abundant fibres, which represent an obstacle to cell sap communication.

The present experimental series was designed to settle the question of whether there is any difference in choline content between plants living on "soft-wood" and the parasites of "hard-wood", taking the vegetation periods into consideration.

With this in view we studied the choline content of the drug:

1. in samples obtained from different host trees growing at the same site, and in their individual organs;

2. in mistletoe parasites of the same species of host tree obtained from different sites, and in their individual organs;

3. in plant material collected from known host trees in different phases of vegetation.

The plant material was collected in 1967 and 1968 in various regions of Hungary in accordance with the various objectives: Somogy county (Transdanubia), Tata (town in Transdanubia), Nyírség (a region east of the river Tisza). The drug was obtained from *Salix caprea* L., *Tilia cordata* Mill., and *Populus canadensis* Moench as "soft-wood" trees, and from *Acer platanoides* L., *Robinia Pseudo-Acacia* L., *Celtis occidentalis* L. and *Juglans nigra* L. as "hard-wood" trees.

The terms "soft-wood" and "hard-wood", which are used to characterize the host trees, represent forestry categories. On the basis of GREGUSS's (1945) work the following reasons can be given for the classification: the ground tissue in the wood of tree species referred to in the paper as "soft-wood" trees is thin-walled xylem fibre, while in the wood of so-called hard-wood trees it is thick-walled xylem fibre. Further anatomic characteristics are as follows: for the soft-wood trees: *Salix caprea*: evenly distributed tracheae; *Tilia cordata*: Mill. wood with scattered pores; *Populus canadensis*: Moench twin-pored wood, thin-walled tracheae; for the hard-wood trees: *Robinia Pseudo-Acacia*: pore rings; *Acer platanoides*: radial pores; *Juglans nigra*: scattered tracheae; *Celtis occidentalis*: pore rings.

The above data also give information on the character of material transport.

Preparation of drug samples. Stem parts more than six-years old were removed from the freshly collected material. Half of the remainder was processed without separation, while the other half was separated into 1—2-year-old shoots and 3—4-year-old stem parts, in accordance with the various objectives of the examination. The drug samples were dried at room temperature, then pulverized to mesh size IV.

Method of examination. a) Paper chromatography. Paper: Whatmann No. 1; ascending method at 22°C; mixture: butanol : ethanol : acetic acid : water (8 : 2 : 1 : 3); reagent solution: Dragendorff reagent; test material: 1% aqueous dilution of choline chloride.

Quantitative determination of choline: in the form of Reinecke precipitation, gravimetrically (LAUFKE 1957, BAYER *et al.* 1958, KATONA 1958). The standard deviation of the examination data is below 5%.

1. In the case of mistletoe collected from "soft-wood" trees the drug samples contained much more choline than those obtained from mistletoe living on "hard-wood" trees (an average of 0.236% in the former compared to an average of 0.148% in the latter, which means a difference of 37.2%).

Within drugs divided into young shoots and older stems, irrespective of the host tree,

Table 1

Analytical material

1. Samples collected from soft-wood trees

Number of drug sample	Host plant	Place	Time
		of collection	
1.	*Salix caprea* L.	Somogy	November 1967
2.	*Tilia cordata* Mill.	Somogy	November 1967
3.	*Populus canadensis* Moench	Somogy	November 1967

2. Samples collected from hard-wood trees

4.	*Acer platanoides* L.	Somogy	November 1967
5.	*Robinia Pseudo-Acacia* L.	Somogy	November 1967
6.	*Celtis occidentalis* L.	Somogy	November 1967
7.	*Juglans nigra* L.	Somogy	November 1967

this difference is naturally shown in the higher choline contents of the younger organs. As for the different organs, the choline content of young leafy shoots of mistletoe living on soft-wood was 6.5% higher, while that of mistletoe shoots obtained from hard-wood trees was 14% higher than that of stem parts more than 3—6-years-old.

Having compared the total choline contents of drugs obtained from soft-wood and hard-wood trees we examined the distribution of the choline content in the young shoots and older stem parts and found similar differences (Tables 1, 2). The choline content of young shoot averaged 0.251% in mistletoe living on soft-wood and 0.164% in drugs obtained from hard-wood trees, compared to choline contents of 0.234 and 0.139%, respectively in older stem parts.

Accordingly, in mistletoe living on hard-wood the young shoots contain 34.7% less and the older stem parts 40.6% less choline than those obtained from soft-wood trees. If the different drug samples are further considered, in the case of soft-wood we found the lowest choline content (0.202%) in mistletoe obtained from *Populus canadensis*, and the highest (0.264%) in those collected from *Tilia cordata*, with regard to both the leafy shoot, the 3—6-year-old stem, and the total drug.

Of the mistletoe collected from the four hard-wood tree species that obtained from *Juglans nigra* showed the lowest choline content (an average of 0.13%), while those living on *Celtis occidentalis*, *Robinia Pseudo-Acacia* and *Acer platanoides* contained on average 0.137, 0.158 and 0.169% choline, respectively (Tables 1, 2).

On the basis of the above an interesting correlation was found between the choline content of the drug and the hardness of the wood in the host tree species. Of all the host trees mentioned *Juglans nigra* L. has the hardest wood. *Celtis occidentalis* L. is somewhat inferior to it in the hardness of its wood, then comes *Robinia Pseudo-Acacia* L., with *Acer platanoides* L. the last in the order of succession. Of the soft-wood trees *Tilia cordata* Mill. has the softest wood, preceding both *Salix caprea* L. and *Populus canadensis* Moench as regards the looseness of the tissue elements, which is reflected in the choline synthesis of the mistletoe living on them.

Examining the choline content of the drug in this context, we found that the choline content of the mistletoe decreases with the increasing hardness of the wood in the host tree both in the young shoots and the older stem parts (Figs 1, 2).

Table 2

Choline contents of mistletoes collected from different host tree species at the same site

Number of drug sample	Host tree	Choline content of: total drug (%)	1–2 years old leafy shoot (%)	3–6 years old stem (%)	difference between younger and older organs (%)
	Soft-wood				
1.	*Salix caprea* L.	0.263	0.272	0.256	5.9
2.	*Tilia cordata* Mill.	0.245	0.264	0.240	9.1
3.	*Populus canadensis* Moench	0.202	0.218	0.208	4.5
	Average %	0.236	0.251	0.234	6.5
	Hard-wood				
4.	*Acer platanoides* L.	0.169	0.182	0.163	10.4
5.	*Robinia Pseudo-Acacia* L.	0.158	0.175	0.137	21.7
6.	*Celtis occidentalis* L.	0.137	0.156	0.133	13.7
7.	*Juglans nigra* L.	0.130	0.144	0.124	13.4
	Average %	0.148	0.164	0.139	14.0
	The choline content in drug samples obtained from hard-wood trees is less by	37.2	34.7	40.6	per cent than in those collected from soft-wood trees

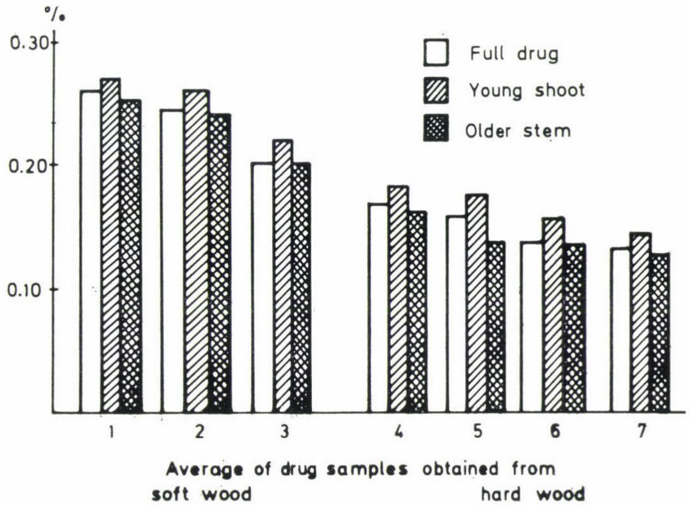

Fig. 1. Effect of different host trees living at the same site on the choline content of the drug

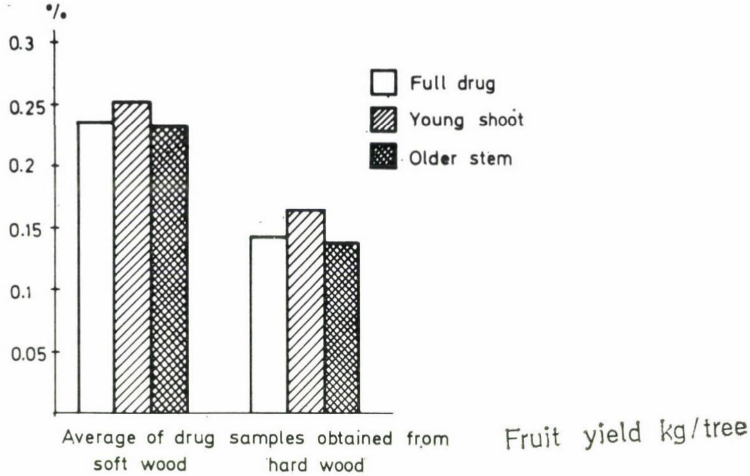

Fig. 2. Effect of different host trees living at the same site on the choline content of the drug. (Average of samples Nos 1—7)

2. In studying the distribution of the choline content in the different organs of mistletoe living on *Populus canadensis* growing at various sites-we tried to find an answer to the question of whether it was uniformly influenced by the ecological conditions. We found that in the drug sample collected in the Nyírség the choline content was higher in all the plant organs.

The choline level was the highest in the tiny leaflets found in the terminal bud (0.628, 0.596 and 0.441%, respectively), followed by the terminal bud with choline contents of 0.348, 0.328 and 0.264%.

The choline content was invariably higher in the young shoots than in the 3—6-year-old stem parts (by 9.5, 10.3 and 4.8%, respectively) irrespective of the influence of ecological factors (Table 3).

Table 3

Choline content in drugs collected from the same host tree species in different regions of Hungary*
(Percentage choline content in the different organs)

Number of drug samples	Site of origin	Choline content % in					
		total drug a	young shoot b	old stem c	leaf d	leaf primordia e	terminal bud f
5	Somogy	0.210	0.218	0.208	0.229	0.441	0.264
			b — c in % = 4.8		e — d in % = 92.5		
6	Tata	0.230	0.246	0.223	0.255	0.596	0.328
			b — c in % = 10.3		e — d in % = 133.7		
7	Nyírség	0.247	0.258	0.235	0.276	0.628	0.348
			b — c in % = 9.5		e — d in % = 127		

* Host tree: *Populus canadensis* Moench

Table 4

Changes in the choline content during vegetation

A) *In drugs obtained from soft-wood*

Number of drug sample	Host tree	Time of collection	Total drug	1–2-years-old shoot	3–6-years old-stem
			%		
2.	*Salix caprea* L.	May	0.244	0.250	0.238
		August	0.252	0.259	0.241
		November	0.260	0.270	0.252
		February	0.276	0.283	0.272
4.	*Tilia cordata* Mill.	May	0.235	0.237	0.228
		August	0.240	0.248	0.236
		November	0.248	0.256	0.242
		February	0.268	0.274	0.258
		B) *In drugs obtained from hard-wood*			
9.	*Acer platanoides* L.	May	0.168	0.175	0.164
		August	0.176	0.180	0.167
		November	0.180	0.189	0.172
		February	0.187	0.197	0.184
11.	*Robinia Pseudo-Acacia* L.	May	0.158	0.171	0.148
		August	0.165	0.181	0.154
		November	0.171	0.183	0.163
		February	0.179	0.187	0.171

3. At the end of our experimental series, we followed the changes in the choline content in the course of the vegetation period in samples collected from "soft-wood" and "hard-wood" trees. We aimed at determining the optimum time for collecting the drug, since *Viscum album* found on both types of tree is required for commercial purposes.

The lowest choline content was found in each case in plant material collected in May, when the development of the new foliage started after the winter period. From that time on the choline content gradually increased, reaching a maximum by the end of the vegetation period in February (Table 4).

All these results confirm our hypothesis that, apart from the meteorological and ecological conditions, the tissue structure of the host tree as well as the absorbed nutrients and the process of transpiration may influence the choline content of mistletoe.

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PHENOTYPIC STABILITY OF SEED YIELD IN LINSEED (LINUM USITATISSIMUM L.)

Linseed is extensively grown as an oil-seed crop in the northern (Indogangetic) and central (peninsular) parts of India, under varied agroclimatic conditions. It is, therefore, necessary for the linseed breeder to test a variety for stable performance in both these regions before it can be recommended for general cultivation. In recent years, it has been possible to measure the genotype environment interaction as a linear function of environmental means.

In order to assess the performance of newly bred genotypes of linseed in these representative areas, their stability parameters were studied using the regression approach developed by EBERHART—RUSSELL (1966). The results of this study are reported in the present article.

Bulk populations were developed from single and three way crosses between Indogangetic and peninsular varieties and between Indian and exotic varieties of linseed, in order to

Table 1

Combined analysis of variance for plot yield in linseed

Source	d.f.	MSS	F
Varieties	13	4 264.94	1.89*
Environments	6	636 271.66	281.46**
Vars. x envs.	78	2 260.62	3.93**
Regressions	13	2 918.56	1.37+
Remainder	65	2 129.04	3.70**
Pooled error	273	575.00	

* Significant at 5%; ** significant at 1%
\+ Non-significant against remainder MSS and significant at 1% against pooled error

breed wilt and rust resistant types. Seeds of morphologically similar genotypes from the population of each cross in an advanced generation were mixed, the progenies of which gave rise to Bulk Selection series (B. S. Nos.). Twelve such B. S. Nos., along with two control varieties, S.36 and T-397, constituted the material of the present experiment. They were grown at seven locations in Mauranipur (UP), Thasra (Gujrat), Ghazipur (UP), Kanpur (UPIAS, UP), Kanpur (RRS, UP) and Varanasi (UP). Although the locations were selected from only two states (indicated in parenthesis), the locations were agroclimatically different within each state. Each experiment was conducted in a randomised complete block design with four replications during the winter season of 1967—68. A plot consisted of five rows each 3.5 m in length with 30 cm and 15 cm as interrow and intrarow spaces. The plot yield in grams was measured on bulked seed of the middle three rows.

Stability parameters for yields of individual varieties were computed using the following model derived by EBERHART and RUSSELL (1966):

$$Y_{ij} = u_i + B_i I_j + \delta_{ij},$$

Where X_{ij} = mean yield of ith variety at jth environment,
u_i = mean of ith variety over all environments,
B_i = regression coefficient of ith variety, which measures the response of ith variety to several environments,
δ_{ij} = deviation from regression of ith variety at jth environment,
I_j = environmental index obtained as the mean of all the varieties at jth environment minus grand mean.

The regression coefficient was estimated by regressing the yield means (Y_{ij}) for a variety from seven respective locations onto corresponding environmental indices (I_j).

The details of computation of these parameters have been described by EBERHART—RUSSELL.

The variety environment (VE) interaction was significant against the pooled error, indicating that the varieties responded significantly to the varying environments. Significant VE interaction is prerequisite for the type of analysis under study. After ascertaining that VE interaction was significant, varieties and environments were tested against VE interaction. The significant differences were observed between the varieties as well as between the environments. VE interaction was further divided into its linear and non-linear (residual) components. Both were significant against the pooled error, suggesting that VE interaction was attributable

Table 2

Phenotypic performances of fourteen varieties of linseed in seven locations with their overall means ($\bar{X}$), regression coefficients (b), standard errors of regression coefficients (S_b) and deviations from regressions ($\bar{s}_d^2$)

Variety \ Location	Mauranipur	Thasra	Bardoli	Ghazipur	Kanpur (UPIAS)	Kanpur (RRS)	Varanasi	Mean ($\bar{X}$)	Reg. coeff. (b)	Standard error (S_b)	Dev. from reg. ($\bar{s}_d^2$)
B.S.2	106	225	95	427	471	709	254	335.3	0.98**	0.07	590.89
B.S.3	87	281	56	320	446	702	283	310.7	1.02**	0.06	354.79
B.S.10	98	218	75	363	460	824	271	329.9	1.19**	0.08	1309.59**
B.S.11	77	243	56	273	437	748	276	301.4	1.08**	0.10	1988.76**
B.S.12	76	242	70	509	480	642	277	328.0	1.00**	0.12	3295.54**
B.S.14	70	225	40	311	389	712	223	281.4	1.05**	0.06	398.28
B.S.25	40	175	56	310	375	513	260	247.0	0.79**	0.06	559.86
B.S.30	74	237	72	476	422	644	247	310.3	0.98**	0.10	2002.31**
B.S.33	99	218	67	473	417	629	253	308.0	0.94**	0.10	2171.04**
B.S.39	82	281	42	285	416	574	259	277.0	0.84**	0.07	890.34*
B.S.44	77	375	65	307	452	720	276	324.6	1.02**	0.12	3368.03**
B.S.50	103	243	95	316	465	711	284	316.7	1.00**	0.07	589.67
S.36	80	243	67	445	470	619	251	310.7	0.96**	0.08	1296.77**
T-397	79	300	78	386	494	757	218	330.3	1.13**	0.06	499.64
Mean	86.3	250.4	66.7	371.5	442.4	678.9	259.4	307.9			
S.E.								±17.97			
C.D.								49.24			
Environmental index	−221.6	−57.5	−241.2	63.6	134.5	370.9	−48.5				

* Significant at 5%; ** significant at 1%

to linear as well as to non-linear components. BREESE (1969) referred to these components as the predictable and non-predictable parts of VE interaction, respectively. These results are summarized in Table 1.

The performance of a variety under varying environments was measured with the aid of the following parameters: (1) mean of the variety over all the environments ($\bar{X}$), (2) regression coefficient (b), and (3) deviation from regression ($\bar{s}_d^2$). According to EBERHART—RUSSELL (1966), a stable variety is one that shows high mean unit regression ($b = 1.0$) and minimum possible deviation from regression ($s_d^2 = 0$). In the context of these considerations, there were four varieties, namely, B.S.2, B.S.10, B.S.12 and T-397 that showed a relatively better performance when their mean values were compared with the grand mean (307.9 ± 17.97). Of these, B.S.10 and B.S.12 had significant deviations from their regressions and therefore, their superior performance could not be accounted for by the linear component of VE interaction (Table 2). For the remaining two varieties, B.S.2 and T-397, the VE interaction was largely due to the linear part, as their deviations from the regressions were non-significant. However, no significant difference was observed between these two varieties in respect of their mean yield (CD= 49.24). Since their regression coefficients did not differ significantly from unity, the two varieties can be considered stable both for favourable and non-favourable environments, which were measured in terms of plus and minus environmental indices, respectively.

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THE EFFECT OF GIBBERELLIC ACID ON GROWTH OF DATURA METEL L.

One of the most important medicinal plants is *Datura metel* L. Although a lot of work dealing with the influence exerted by gibberellic acid on plant growth has been conducted on several species of *Datura*, the literature concerning *Datura metel* in this respect is still scanty. Most of the data available in this area of research point to the stimulative effect of GA on growth in certain species of *Datura* (SMITH—SCIUCHETTI 1959, AMBROSE—SCIUCHETTI 1962).

The work reported herein was carried out to investigate the influence exerted by GA_3 upon certain aspects of growth in *Datura metel.*

Since the method of treating the plants with growth regulators is likely to determine the nature of the response shown by the growth, the GA_3 was supplied to the plants throughout the present investigation by two methods. One of them involved soaking the seeds in the growth substance before sowing, whereas in the second, the same compound was added to the plants as a foliar spray.

This study was carried out on *Datura metel* in the 1970 season, then repeated in that of 1971, at the Farm of the Botany Laboratory, National Research Centre, Cairo, Egypt.

The seeds were sown in seed beds on March 23rd in both seasons. The seedlings were transplanted one month after sowing into clay pots (25.4 cm in diameter) containing fresh Nile silt and sand in the proportion of 3 : 1. A mixture of fertilizers was added consisting of 4g ammonium sulphate, 5 g superphosphate and 2 g potassium sulphate per pot. In both seasons there were four replicates for each of the concentrations (treatments) used. Each replicate was represented by 7 pots, each containing two plants, more or less homogeneous at the start of experimentation. The replicates were arranged in a complete randomized block design.

GA_3 (Gibberellic acid) was applied in both seasons by one of the following methods:

1. Spraying: the seedlings were sprayed twice, once 3 weeks after transplantation, and again a week later. Spraying was carried out using a small pressure pump. Just sufficient of the solution was sprayed to completely cover the plant foliage until it began to drip.

2. Soaking: the seeds were soaked before sowing for 12 hours in the growth regulator used.

For both types of application four GA_3 concentrations were employed: 0 (control), 25, 100 and 400 ppm (in distilled water).

The estimation of plant height (main stem) as well as counting the number of either branches or leaves (per plant) were carried out in both seasons at 7-day-intervals (beginning from the 11th week after sowing in the case of plant height or the number of leaves, and from the 13th week after sowing in the case of the number of branches). In addition, three samples were taken from each treatment, at about one-month-intervals. The first was harvested at late vegetative growth (about 84 days from planting); the second sampling took place during flower-bud opening (fruit setting has not yet begun at that time), whereas the third sample was taken during fruit maturation (meanwhile, the plants sampled might still carry some flowers that had not yet set fruits). At the first sampling date (in both seasons), eight plants from four pots were used, whereas at both the second and third sampling dates, four plants from four different pots were taken. The roots were carefully cleaned from sand and silt particles. Each plant was separated into leaves, stems including lateral branches, and roots. The detached organs were oven-dried at 105°C for 24 hours, then the dry weight was determined.

The data presented in Tables 1, 2 and 3 show that GA_3, applied either as a spray or as a soaking medium, generally led to a stimulating effect on the growth, as well as on the number of either branches or leaves per plant. In most cases this stimulating effect appeared to become much more pronounced as the GA_3 concentration was increased.

Concerning the changes indicated in dry weight, as shown in Table 4, it might be preferable to compare the values obtained at the last sampling date only (i.e. at the fruit maturation stage). This would seem to be of more benefit in showing how the different methods of applying the growth substance could affect the net accumulation of dry matter throughout the growth period. Such values (Tables 4 and 5) revealed that the application of GA_3, whether as a spray or as a soaking medium, tended in most cases to stimulate the dry matter accumulation in either leaves or stems. In addition, it appeared in both seasons, though the differences were statistically insignificant, that the dry weight of the roots also tended to be increased, so long as the GA_3 was applied as a soaking medium; but an opposite picture was generally obtained for this organ in the same respect when using the spraying method. Furthermore, it was shown that the stimulating effect caused by GA_3 on the dry matter accumulation in different organs was most obvious at its highest level, except in the case of stems when using the spraying method, when the highest values obtained resulted from the lowest concentration.

Our data concerning the positive response of growth to GA_3 treatments are in harmony with many findings on *Datura* plants (James—Sciuchetti 1964, Said *et al.* 1964). Furthermore, the trend observable in the literature in this regard points in most cases in the same direction (Smith—Sciuchetti 1959 on *Atropa belladonna*, Baz 1970 on *Gerbera Jamesonii*, Srivastava—Adhikari 1972 on onions).

According to our results, the stem dry weight at the fruit maturation stage was generally shown to be increased due to GA_3 application. This observation agreed with other findings

Table 1

Average plant height of D. metel plants (cm/plant) as affected by different GA_3 treatments

GA_3 conc. (ppm)	Plant age (weeks from sowing)																	
	11		12		13		14		15		16		17		18		19	
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b
1970 season																		
0	7.5	4.7	11.8	8.9	18.9	12.0	23.9	17.9	26.8	26.1	28.1	29.1	29.6	30.0	30.2	37.7	33.5	39.5
25	9.5	6.9	15.4	10.3	23.5	16.1	26.7	21.4	29.1	26.3	29.1	29.7	30.0	33.1	32.7	38.7	36.5	41.8
100	10.6	8.2	16.5	14.9	25.0	22.7	33.3	27.1	34.8	33.0	36.2	35.9	37.8	39.4	41.7	40.7	42.5	44.3
400	10.4	8.5	19.9	13.2	31.1	23.5	36.0	29.5	39.1	39.9	42.0	40.2	42.1	42.9	42.9	49.6	48.6	55.0
L.S.D. at 5% level	N.S.	1.5	4.8	2.4	4.5	3.4	5.5	3.9	4.3	4.6	8.0	6.9	7.7	6.9	5.2	7.0	9.6	5.2
1971 season																		
0	16.6	10.6	25.4	19.5	29.6	24.5	32.6	30.1	34.9	34.0	35.6	36.1	39.4	38.2	40.0	40.1	43.2	43.7
25	19.9	10.6	28.6	19.3	34.5	25.1	37.2	31.8	42.7	35.8	43.9	39.1	45.1	39.3	50.5	41.9	51.3	4.47
100	23.5	11.0	34.8	19.7	40.6	26.0	42.6	32.8	48.0	36.5	50.0	39.7	57.2	42.6	61.6	43.6	61.6	46.0
400	24.2	11.8	35.7	21.0	43.5	26.2	47.5	33.4	52.0	38.0	55.0	42.0	60.2	45.4	62.5	45.5	63.5	47.5
L.S.D. at 5% level	2.3	0.8	3.2	N.S.	2.5	N.S.	2.6	N.S.	3.6	N.S.	13.2	3.7	1.6	2.5	2.6	N.S.	5.4	N.S.

a = spraying
b = soaking

Table 2

Average number of branches per plant in D. metel as affected by different GA_3 treatments

GA_3 conc. (ppm)	Plant age (weeks from sowing) 13 a	13 b	14 a	14 b	15 a	15 b	16 a	16 b	17 a	17 b	18 a	18 b	19 a	19 b
1970 season														
0	2.5	1.3	3.3	2.0	4.8	3.3	6.6	4.9	7.0	5.7	7.7	7.6	9.8	10.7
25	2.6	0.0	5.0	0.0	5.5	4.0	7.3	5.3	8.3	6.2	9.0	8.8	9.0	11.2
100	2.7	2.0	5.6	2.1	7.8	5.4	8.3	8.0	9.6	10.8	12.4	11.3	12.4	12.5
400	2.8	2.7	6.7	3.3	11.0	7.5	12.3	9.3	13.1	12.0	16.7	13.5	20.2	15.0
L.S.D. at 5% level	N.S.	1.2	2.2	1.1	3.6	2.9	3.9	2.7	3.1	3.2	3.5	2.7	2.6	2.9
1971 season														
0	4.9	3.7	5.3	4.6	6.5	4.9	8.0	5.9	9.7	6.4	11.5	9.9	12.6	10.3
25	6.0	2.6	8.0	3.8	8.9	4.9	11.6	6.7	13.2	6.9	15.3	10.4	18.8	11.6
100	6.7	4.0	8.2	4.2	8.9	5.2	12.1	7.2	14.8	7.3	18.3	11.1	21.1	12.3
400	7.8	4.4	8.3	5.7	9.3	6.6	15.0	7.5	16.9	10.1	19.9	12.7	24.5	14.7
L.S.D. at 5% level	1.0	1.2	1.1	1.1	1.3	N.S.	1.7	N.S.	0.9	1.8	2.1	N.S.	1.9	N.S.

a = spraying
b = soaking

Table 3

Average number of leaves per plant in D. metel as affected by different GA_3 treatments

GA_3 conc. (ppm)	Plant age (weeks from sowing)																	
	11		12		13		14		15		16		17		18		19	
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b
	1970 season																	
0	5.3	5.7	8.0	7.2	11.1	8.3	13.9	9.0	14.4	12.4	14.6	13.4	16.8	15.5	18.5	24.4	19.3	26.4
25	5.3	5.7	8.2	7.6	12.5	9.0	14.7	10.0	16.1	13.7	19.5	15.5	19.9	20.5	20.1	24.7	22.3	29.6
100	5.4	6.4	8.7	9.8	13.0	10.5	16.3	12.3	22.1	16.7	22.2	18.4	22.4	24.0	27.9	25.8	31.0	31.5
400	5.7	7.2	9.7	9.8	14.6	10.9	18.7	13.5	31.6	17.4	43.3	19.4	39.9	27.9	43.6	28.0	45.3	34.6
L.S.D. at 5% level	N.S.	N.S.	N.S.	1.4	2.3	2.2	3.4	2.5	5.0	2.8	5.0	2.5	5.6	5.1	4.3	N.S.	7.8	N.S.
	1971 season																	
0	8.8	8.0	13.8	11.5	14.2	13.8	18.7	15.6	22.3	18.4	22.6	20.0	23.0	23.5	24.9	24.7	27.8	29.5
25	9.8	7.9	15.3	11.1	17.4	13.0	20.1	16.9	26.2	19.2	29.0	21.1	37.8	24.3	39.3	27.0	42.4	30.1
100	11.5	8.1	15.6	11.6	17.8	14.9	21.1	17.3	30.5	19.8	31.9	22.7	38.4	26.4	39.4	29.1	48.1	30.6
400	12.0	8.2	15.9	12.0	21.8	16.0	22.3	18.1	31.2	20.5	34.8	27.3	45.4	30.0	47.8	31.2	52.4	35.7
L.S.D. at 5% level	1.2	N.S.	N.S.	N.S.	1.8	1.8	N.S.	N.S.	2.6	N.S.	2.9	5.4	2.5	N.S.	1.6	N.S.	3.9	N.S.

a = spraying
b = soaking

Table 4

Dry weight of D. metel plants (g/plant) as affected by Ga_3 treatments

Developmental stages		Late vegetative growth		Flower-bud opening		Fruit maturation	
Plant organ	GA_3 conc. (ppm)	Spraying	Soaking	Spraying	Soaking	Spraying	Soaking
1970 season							
Leaves	0	2.6	0.9	7.4	4.6	9.2	9.8
	25	3.0	1.2	9.0	5.9	10.4	11.9
	100	3.2	1.2	9.8	7.4	15.1	12.5
	400	3.4	1.7	10.3	7.1	15.6	14.6
	L.S.D. at 5% level	N.S.	N.S.	N.S.	N.S.	4.8	N.S.
Stems	0	0.5	0.2	3.3	1.9	7.1	7.2
	25	0.6	0.2	5.1	2.3	8.5	7.6
	100	0.7	0.2	4.3	4.0	8.1	10.2
	400	1.2	0.3	3.8	4.0	7.2	12.8
	L.S.D. at 5% level	0.4	N.S.	N.S.	1.6	N.S.	2.3
Roots	0	0.6	0.2	3.1	1.9	6.2	5.4
	25	0.7	0.3	3.4	2.0	5.5	6.1
	100	0.6	0.3	3.0	4.2	5.3	6.9
	400	0.6	0.4	3.0	4.4	4.5	7.3
	L.S.D. at 5% level	N.S.	N.S.	N.S.	1.2	N.S.	N.S.
1971 season							
Leaves	0	3.6	2.4	8.2	7.1	7.4	7.5
	25	4.0	2.8	8.6	7.1	9.4	7.6
	100	4.3	2.9	8.9	7.2	9.9	7.6
	400	4.3	3.2	9.2	8.7	10.7	8.6
	L.S.D. at 5% level	N.S.	0.5	N.S.	N.S.	1.3	N.S.
Stems	0	1.9	0.8	6.9	4.2	9.1	10.2
	25	3.0	0.7	9.4	4.7	12.8	12.5
	100	3.0	0.9	8.4	4.8	11.8	13.7
	400	3.9	1.4	8.2	5.9	11.2	14.6
	L.S.D. at 5% level	0.7	1.0	1.0	N.S.	2.0	N.S.
Roots	0	1.5	0.6	5.4	3.3	6.4	7.0
	25	1.7	1.0	5.0	4.3	6.4	7.9
	100	1.4	1.1	4.8	4.4	6.2	7.9
	400	1.3	1.4	4.0	4.7	5.5	8.0
	L.S.D. at 5% level	0.4	0.3	N.S.	N.S.	N.S.	N.S.

Table 5

Dry weight of D. metel plants at fruit maturation stage as % of control, (i.e. 0 ppm) as affected by GA_3 treatments

Plant organ	GA_3 conc. (ppm)	1970 season		1971 season	
		Spraying	Soaking	Spraying	Soaking
	25	113.04	121.43	127.03	101.33
Leaves	100	164.13	127.55	133.78	101.33
	400	169.57	148.98	144.59	114.67
	25	119.72	105.56	140.66	122.55
Stems	100	114.08	141.67	129.67	134.31
	400	101.41	177.78	123.08	143.14
	25	88.71	112.96	100.00	112.86
Roots	100	85.48	127.78	96.88	112.86
	400	72.58	135.19	85.94	114.29

on *Datura* plants (Smith—Sciuchetti 1959, Ambrose—Sciuchetti 1962). This increase in dry matter accumulation could be partly attributed to the stimulated growth and partly to the enhanced branching; the latter two types of observation have been obtained in the present as well as in some other investigations (James—Sciuchetti 1964, Said *et al.* 1964). On the other hand, the stimulative effect of GA_3 on the dry weight of leaves (per plant), being shown at the fruit maturation stage in the present study, might have resulted in part from an increase in total leaf area per plant. That GA could lead to a stimulative effect on the number of leaves per plant has been shown in our results as well as in those of some other investigators on *Datura stramonium* (Said *et al.* 1964). Furthermore, in the literature there are certain data indicating the promotive influence of gibberellin on the leaf size of tea plants (Pilet—Wurgler 1958) and tobacco (Gopalachari—Naidu 1961). In this regard it might be added that Hayashi (1961), in experiments with tomato and rice treated with GA, noticed an increase in the photosynthetic activity of the whole plant owing to the increase in leaf area, the photosynthetic activity per unit leaf area being unchanged under these conditions. Based on this type of observation, it may be that a similar increase in the photosynthetic activity per plant has resulted due to the use of GA_3 in our experiments, through an increase in the total leaf area. Such a rise in the photosynthetic activity per plant could have contributed partly to the stimulating effect on dry matter accumulation under such conditions.

Our data obtained at the fruit maturation stage indicated further that the method by which GA_3 applied to the plants appeared to determine to some extent the type of response shown by dry matter accumulation in the roots. Such contradictory effects might be partly interpreted in terms of the auxin level in this organ. There are several reports (Paleg 1965) showing the increase in the auxin level in plants following the application of GA. In the light of this type of observation, it may be that both the spraying and soaking methods of GA_3 application could have raised the auxin concentration in the roots, particularly the former method. It seems further that using the spraying method, the auxin level attained in the roots was supraoptimal, thus retarding the elongation of this organ. In this regard, Thimann (1937) suggested that the roots have a lower threshold of auxin sensitivity. On the other hand, under certain conditions, gibberellic acid could markedly increase the number of laterals initiated and the early growth of these laterals in cultured tomato roots (Street 1966). It might be suggested, in view of such findings, that a similar type of effect resulted when our experimental plants were treated with GA_3, especially when the growth substance was supplied as a soaking medium. The enhancement of lateral root formation thus obtained might be regarded as contributing partly to the increased dry weight of the roots under these conditions.

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DATA ON THE "BLISTERING BREAST" DISEASE OF MEAT CHICKENS KEPT IN CAGES

Poultry breeding in cages has become a wide-spread practice in recent decades. Keeping layers in cage is now considered to be an efficient method. However, raising meat chickens in cages involves many problems, even today. This is because the chickens constantly change until the age of seven–eight weeks, not only in weight and size, but also in quality. These changes must be followed from technical, feeding and veterinary points of view.

Among the technical problems bottom grating is of considerable importance. Meat chickens kept in cages often show a characteristic symptom known, for want of a better name, as "blistering breast". At present the general opinion is that the disease is caused by the metal bottom grating. Replacing the metal grating by one made of synthetic material is an obvious, though not a cheap solution. Experience shows that the disease cannot be totally eliminated even then, not to mention the fact that in deep litter systems similar disorders have been described by OLSON *et al.* (1954), WILLS (1954) and BIGLAND—BROWN (1955), and by DERZSY *et al.* (1960) in Hungary.

Unfortunately, the authors are at a loss as to the pathology of the disease; they consider that it may be infectious, but none of them has succeeded in identifying the pathogen.

It follows that even if the bottom grating plays a decisive role in the development of the disease, this role is not exclusive.

The relevant literature deals, almost without exception, with the frequency of incidence under given circumstances (GRATZL—KÖHLER 1968, LANGVELD 1974, TÓTH *et al.* 1974, etc.).

Very little is said about the nature of the lesion from the point of view of anatomy or pathology. In our opinion, there is little use in searching for technical solutions before the nature of the lesion is known. Without this no efficient prevention can be reasonably expected.

In our experiment we placed 360 Hybro chicks in a two-storey cage system designed and manufactured by the Agricultural Machine Factory, Mosonmagyaróvár. The cages were furnished with metal bottom grills. The chicks were fed with the customary starting and raising mashes with a vitamin supplement added to the drinking water as prescribed by the technology for baby chicks and 2-week-old chicks. At the age of 14 days the stock was immunized with

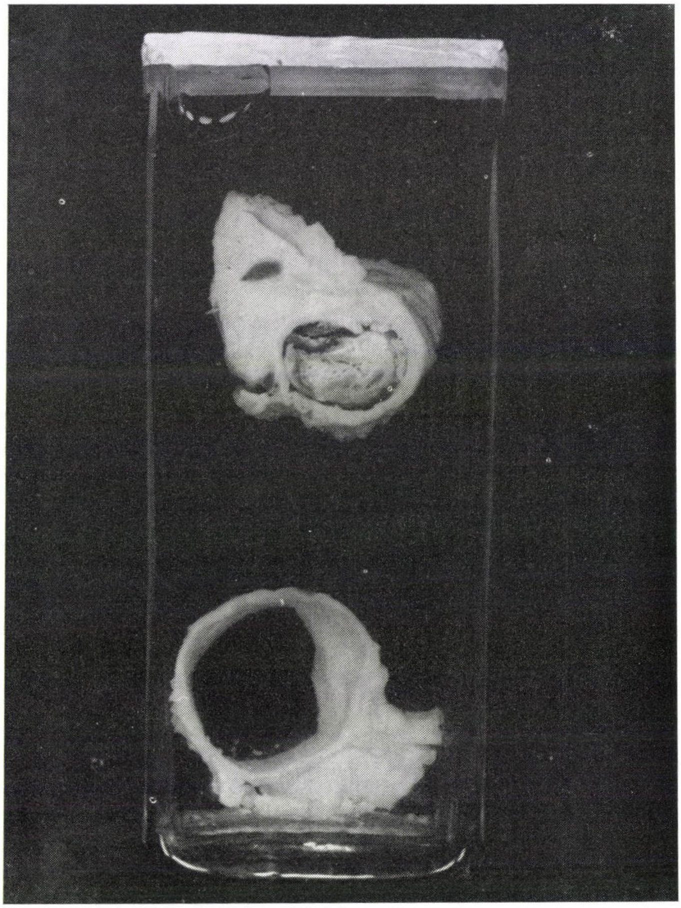

Fig. 1. Sample from an animal at an advanced stage of breast blisters. Above: cross section of a blister filled with a crumbly content; below: cross section of an empty blister with connecting tissue wall. (Natural size)

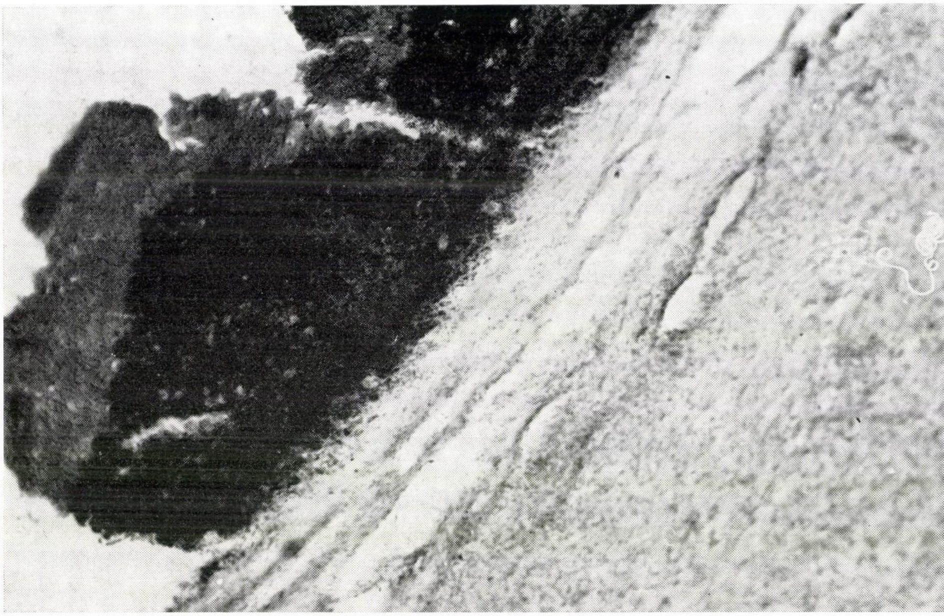

Fig. 2. Wall of a breast blister, and the organic discharge adhering to it. ($\times 85$)

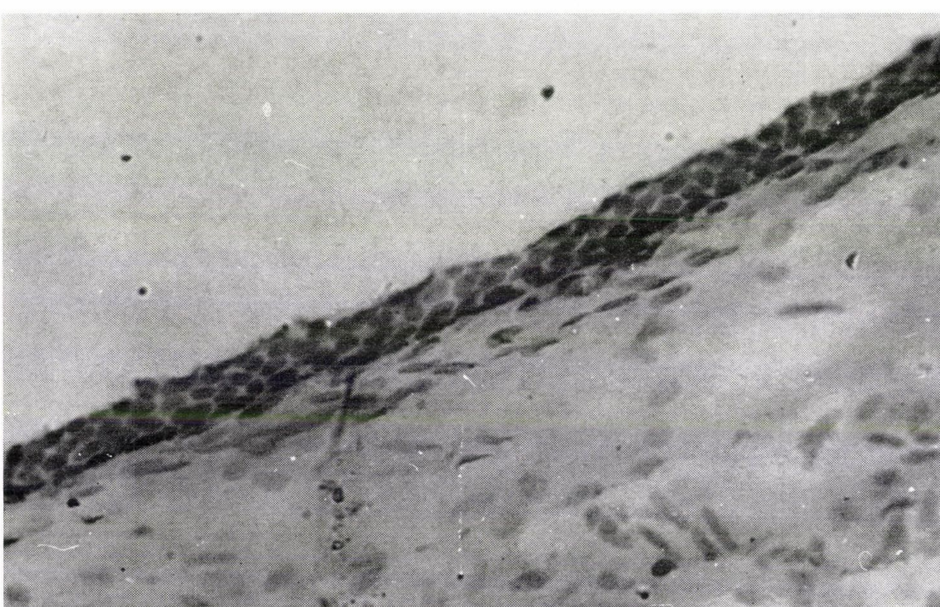

Fig. 3. The inner surface of the blister is covered here and there by the epithelium seen in the picture. ($\times 400$)

"Lavac" vaccine against fowl pest. In creating the necessary ecological conditions the Hybro raising technology was followed. During the raising period the stock was continually examined, especially for breast blisters.

At the end of the fattening period (49 days), the stock from two cages (40 birds) was processed pathologically and histologically. Histological sections were prepared with Reichert's "freezing" microtome and dyed with haematoxilin–eosin. The fluid obtained from the blisters was dyed using the Pappenheim method.

Our main task was to find out whether "breast blisters" occurred under these experimental conditions, and if so to what extent and when, and to establish, if possible, the pathological basis of the disease.

During the raising period the stock was continually examined. According to our observations, the disease first appeared in the middle of the sixth week. On the frontal third of the carinal crest of some chickens undulating formations the size of a pea or hazel-nut appeared.

Having examined the fluid taken from these, the following conclusions could be drawn: The viscous, initially straw-yellow, later reddish fluid showed no tendency to coagulate. The Rivalta test was positive. The protein content analyzed in an early phase was 1.7%. When a smear from the precipitate was dyed it was found to contain a certain number of erythrocytes and mononuclear elements.

The number of birds showing lesions increased day by day, as did the fluid in the "blister", up to 10—15 ml. By the end of the raising period the number of diseased birds exceeded 50%.

On the 49th day the chickens attained the desired weight (an average of 1425 g). However, the carinal crest was found to protrude to a considerable extent, and the muscles attached here were thin and underdeveloped. At the beginning the lesion appeared on the frontal third of the carinal crest, but later it extended over almost the full length. The cavities of the blisters were in many cases partitioned. The bases adhered closely to the carinal crest or to the faciae. At an advanced stage of the disease, the fluid in the blisters may become thick, it then turns into a crumbling substance, and in some places maintains a closer connection with the wall of the cavity. In such cases the wall of the blister develops into a 1—2 mm thick connective tissue capsule which is closely connected to the skin. According to our experience, the skin above the lesion was always intact.

Before marketing the stock 7 cases of acute serous arthritis were found. This was restricted to the tarsal joint. The joint was turgid and full of fluid, undulating to the touch. We also found 8 "crippled" chickens, but our investigations showed that this could be traced back to different reasons. No other disease occurred in the stock.

The location of the lesion, together with anatomical and histological examinations, indicate that it is an enlargement of the carinal bursa developing as a result of an initially acute, then chronic inflammation. (It is known that where there are projecting bone ends either permanent or acquired bursae are to be found, which develop according to the extent of use.)

Here the question immediately arises whether this lesion is a separate disease, or perhaps the symptom or the consequence of a disease. If this question could be answered it might well lead to efficient prevention.

According to literary data — Derzsy *et al.* (1960), Mészáros (1966) — the enlargement of the carinal bursae must also be reckoned with in the case of so-called infective synovitis.

In the papers mentioned, however, there is no reference to bursitis as being either the direct consequence of the infection, or a secondary symptom developing on specimens which spend a lot of time lying down because of painful arthritis.

At present we are inclined to believe that the lesion develops as a consequence of the infection. This belief is supported by the fact that in the case of other painful limb diseases (rachitis), or other diseases which force the animals to lie down a lot (e.g. perosis) the authors do not mention similar consequences. The possibility that lesions develop as a response to purely mechanical effects cannot be excluded. A definite opinion on this question can only be formed on the basis of further experiments.

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THE EFFECT OF GA_3 AND CCC ON THE LEVELS OF ENDOGENOUS PLANT GROWTH SUBSTANCES. I. THE EFFECT OF GA_3 AND CCC ON THE LEVELS OF ENDOGENOUS EXTENSION-GROWTH STIMULANTS AND INHIBITORS IN DIFFERENT WHEAT VARIETIES

Certain trials have been made in the literature to elucidate how either GA (Bouillenne—Leyh,1962, Bastin 1967, Andersen—Muir 1969) or CCC (Kuraishi—Muir 1963, Norris 1966, Ivanova 1970) could modify the auxin levels in plant tissues. However, the publications in this area of research with respect to wheat plants appear to be scanty, particularly with respect to GA. Even the data available concerning the effect of CCC in the same regard are contradictory. It was in view of such considerations, and because hardly any particular attention is paid in the literature to the study of extension-growth inhibitors in GA- or CCC-treated plants, that the present work was conducted. It aimed to study the effect of either GA_3 or CCC on the levels of endogenous growth-stimulating substances (including auxin) and extension-growth inhibitors in the seedlings of different wheat varieties.

The present work was conducted during 1973 in the Institute of Plant Physiology, Aarhus University, Aarhus, Denmark. Four wheat varieties were used: "Progress", "Solo", "Drabant" and "Toyota". The plants were grown in styrofoam boxes, measuring $45 \times 27 \times 7.5$ cm, each being filled with 3.5 kg of fine soil. Plant growth was maintained in a controlled growth chamber at 20°C with a 16-hr period of 20,000 lux from xenon illumination every 24 hr. Fertilization with N, P and K in a ratio of 8 : 2 : 3, respectively, was conducted weekly, starting 15 days after sowing. Such fertilization was achieved through the addition of the nutritive solution at a rate of 32 ml/box/whole growth period. This nutritive solution contained N in three forms, nitrate (3.3%), ammonium (3.4%) and amide (1.0%), together with P (soluble) (1.7%) and K (2.7%). The plants were irrigated with distilled water whenever needed. Seed sowing was on 26th January, at the rate of 80 grains/box. 18 days later (during the tillering stage), thinning was carried out to leave 50 seedlings/box. On the next day, the seedlings were sprayed with gibberellic acid (GA_3) or (2-chloroethyl)trimethylammonium chloride (CCC), using 0.05%. Tween 20 "polyoxethelene sorbitan monooleate" as a wetting agent. The concentrations used were: 10, 50 and 100 mg/l for GA_3, and 100, 500 and 1000 mg/l for CCC. Control plants were sprayed with distilled water (together with the wetting agent). Each of the 28 treatments (7 for each variety) was represented by 2 boxes.

Sampling was conducted on the 41st day after sowing. For this purpose, 100 g fresh weight from the shoot system in each treatment were taken at random. The plants were treated for the extraction of growth substances with 80% redistilled cold methanol at the rate of 10 mg/g fresh weight, then kept at 2°C. After 48 hr filtration was carried out using cheese cloth. The extract was then evaporated under a vacuum at 27°C till the aqueous phase. This phase was adjusted to pH 8.0 using 0.1 N KOH and partitioned three times against an equal volume of ethyl acetate (which was then discarded). The pH of the aqueous phase was adjusted to 2.8 using 1 N HCl and partitioned three times against an equal volume of ethyl acetate. The acidic ethyl acetate fractions were then combined and dried under a vacuum at 27°C to reduce the volume. The ethyl acetate fraction was redissolved in 1 ml methanol and an aliquot equivalent to 5 g fresh weight was loaded across the start lines of 3.5 cm wide strips of Whatman No. 3 paper chromatography. Chromatograms were developed in tanks lined with filter paper using a solvent composed of isopropanol : ammonia : water (10 : 1 : 1 v/v). The chromatograms were air-dried. To test for the indole compounds, the developed chromatograms were sprayed with modified Salkowski reagent consisting of ferric sulphate and sulphuric acid (after EL-ANTABLY 1965). For the determination of extension-growth stimulants and inhibitors, wheat straight-growth assay (BENTLEY—HOUSLEY 1954) was conducted. The results were statistically analyzed according to TUKEY (1953). The data obtained were represented as histograms.

1. Levels of extension-growth stimulants and inhibitors in untreated wheat seedlings

According to Fig. 1 highly significant levels of growth-stimulating substances are present in the extracts of the four varieties. A peak of activity was observed in the extracts of the varieties "Progress", "Solo" and "Drabant", being observed at R_{fs} 0.1—0.4, 0.1—0.3 and 0.1—0.3, respectively. Meanwhile, two peaks of activity were detected in the extract of the variety "Toyota" at R_{fs} 0.0—0.1 and 0.2—0.3. Concerning the quantitative differences, the highest growth-stimulating activity was shown in the variety "Progress", whereas the reverse proved to be true in "Solo".

From Fig. 1 it appears further that significant levels for the extension-growth inhibitors were detected in the two varieties "Progress" and "Drabant", at R_{fs} 0.4—0.5, 0.7—0.8 and 0.9—1.0 for "Progress" and 0.9—1.0 for "Drabant". On the other hand, no significant activity was detected for extension-growth inhibitors in the varieties "Solo" and "Toyota".

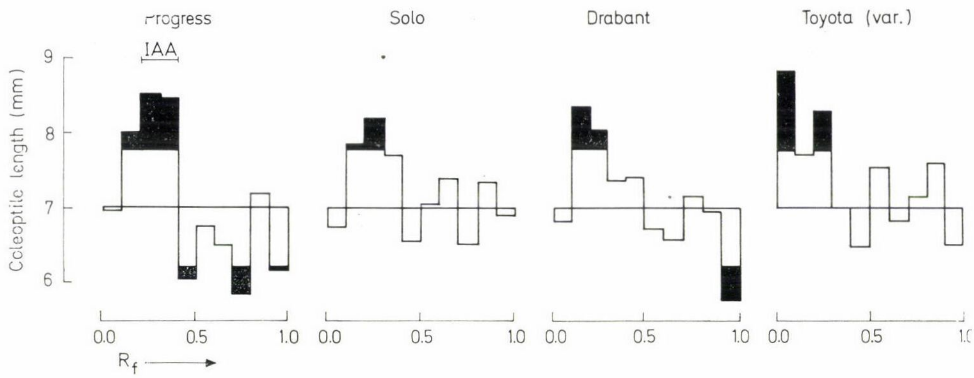

Fig. 1. Distribution of activities of growth-stimulating substances and inhibitors on chromatograms, developed with isopropanol:ammonia:water (10:1:1 v/v), of extracts of four varieties of wheat seedlings. The wheat straight-growth assay was used for estimation. The location of a marker spot for IAA is shown by a horizontal bar. Shaded parts represent biological activity at a 1% level of significance

2. Levels of extension-growth stimulants and inhibitors in wheat seedlings treated with GA_3

From Figs 1 and 2 it appears that in the variety "Progress", GA_3 at the lowest and highest levels led to a remarkable decrease in growth-simulating activity, compared with the controls. Such activity was detected at R_{fs} 0.0—0.1 and 0.3—0.5 for the lowest and 0.0—0.1 and 0.2—0.3 for the highest GA_3 level. A similar decrease in this respect was indicated, though undetected, in the case of the medium GA_3 concentration, the growth-stimulating activity being noticed at R_{fs} 0.0—0.2 and 0.3—0.4. The response of the activity of endogenous growth-stimulating substances to GA_3 in the variety "Solo", compared with the controls, also depended upon the dose applied. Thus, whereas a stimulatory effect was shown at both the medium and the high GA_3 concentrations, no significant activity was observed at the lowest one. The R_{fs}-values indicated for growth-stimulating substances were: 0.0—0.1 and 0.2—0.6 in the case of 50 mg/l and 0.0—0.1 and 0.2—0.3 for 100 mg/l. The growth-stimulating activity was similarly lower than in the controls in the case of the variety "Drabant" when applying the lowest GA_3 concentration; the medium and high concentrations, however, appeared to be stimulatory in this respect. The R_{fs}-values indicated for growth-stimulating substances were located at 0.0—0.1 for the lowest dose, at 0.1—0.5 and 0.8—1.0 for the medium one, and at 0.1—0.2 and 0.3—0.4 for the highest concentration. The only case where the lowest GA_3 concentration could lead to an increase in growth-stimulating activity compared with the controls was noticed in the variety "Toyota". The activity in this case was concentrated at R_{fs} 0.2—0.6. A similar increase in the same respect was indicated in the case of the medium GA_3 concentration, the growth-stimulating activity being noticed at R_{fs} 0.1—0.2 and 0.3—0.5. On the other hand, the application of the highest GA_3 concentration led to an inhibitory effect on growth-stimulating activity compared with the controls; this activity was located at R_{fs} 0.2—0.3 and 0.4—0.5.

On the other hand, it can be generally noticed from Fig. 2 that significant zones of inhibitors were detected when using either the 10 or 100 mg/l GA_3 concentrations in both "Progress" and "Solo". However, no significant inhibitors occurred at any GA_3 doses in either "Drabant" or "Toyota", or at 50 mg/l GA_3 in either "Progress" or "Solo".

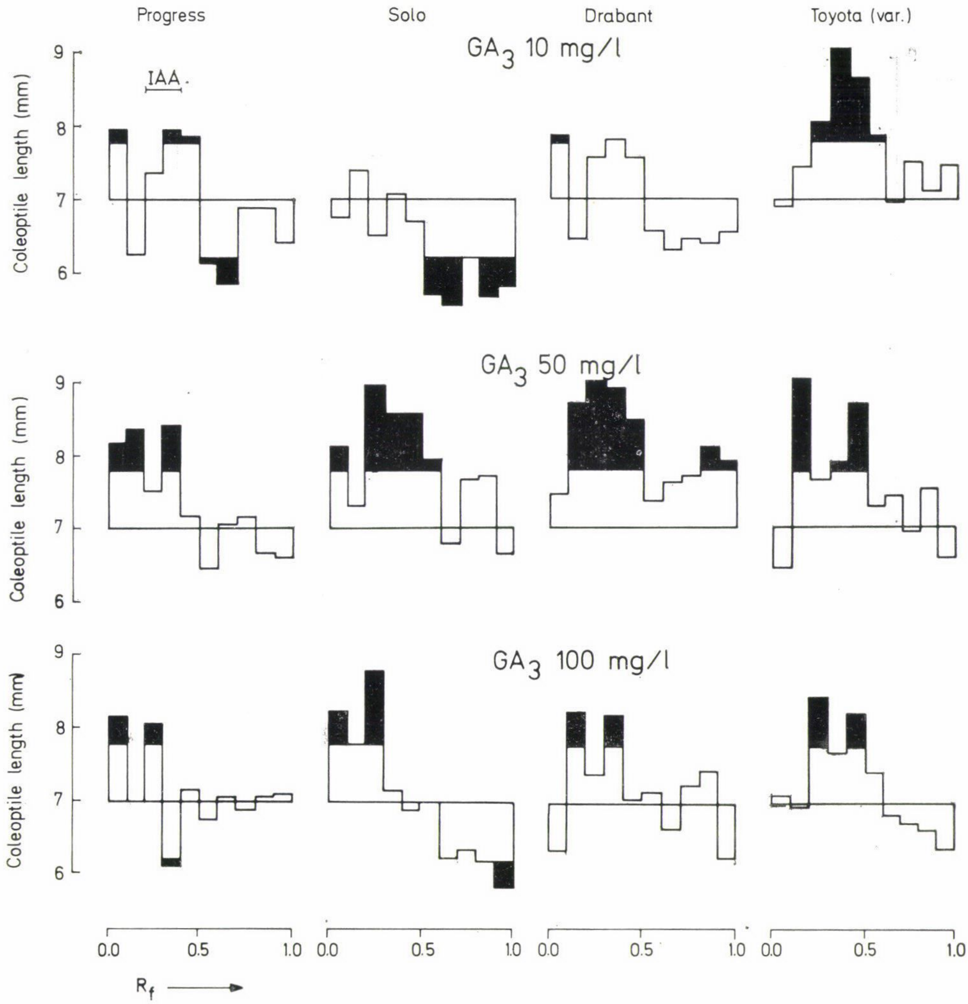

Fig. 2. Distribution of endogenous growth-stimulating substances and inhibitors on chromatograms of extracts of four varieties of wheat seedlings treated with three GA_3 concentrations; the chromatograms were developed with isopropanol:ammonia:water (10:1:1 v/v). The wheat straight-growth assay was used for estimation. The location of a marker spot for IAA is shown by a horizontal bar. Shaded parts represent biological activity at a 1% level of significance

3. Levels of extension-growth stimulants and inhibitors in wheat seedlings treated with CCC

From Figs 1 and 3 it can be shown that CCC application to wheat seedlings of the four varieties appeared consistently to lower the activity of endogenous growth-stimulating substances compared with the controls, though a few exceptions were observed. With the variety "Toyota", this lowering effect was much more distinct at the low and high CCC concentrations than at the medium one. The activities were located at R_{fs} 0.0—0.1; 0.4—0.5 and 0.8—1.0; and 0.4—0.5 for the low, medium and high concentrations, respectively. With respect to the

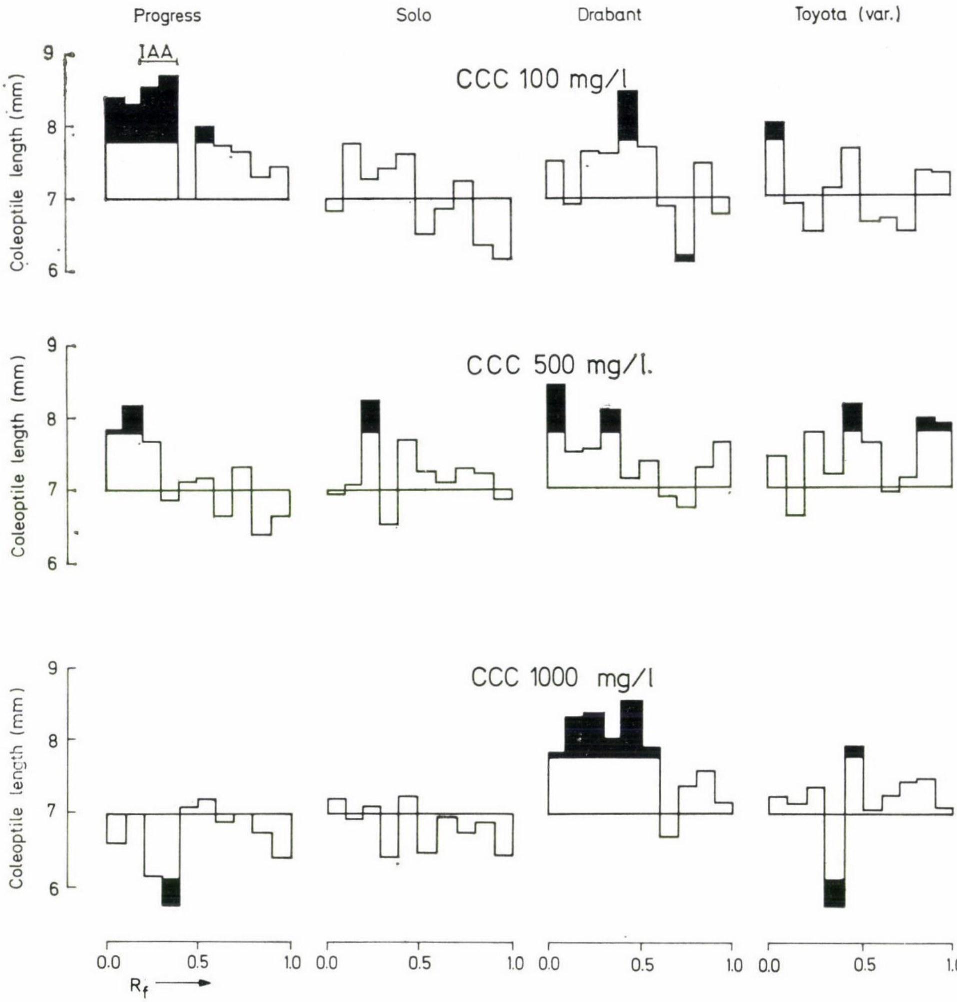

Fig. 3. Distribution of endogenous growth-stimulating substances and inhibitors on chromatograms of extracts of four varieties of wheat seedlings treated with three CCC concentrations; the chromatograms were developed with isopropanol:ammonia:water (10:1:1 v/v). The wheat straight-growth assay was used for estimation. The location of a marker spot for IAA is shown by a horizontal bar. Shaded parts represent biological activity at a 1% level of significance

exceptional behaviour referred to above, i.e. a rise in the activity of endogenous growth-stimulating substances, it was the lowest concentration that caused a promoting effect in the variety "Progress" and the medium and high concentrations in "Drabant". The activity of growth-stimulating substances under such conditions was located at R_{fs} 0.0—0.4 and 0.5—0.6 for "Progress" treated with low concentration and 0.0—0.1 and 0.3—0.4, and 0.0—0.6 for "Drabant" treated with medium and high concentrations, respectively.

From Fig. 3 it appears further that significant levels for the extension-growth inhibitors were detected only in the varieties "Solo" and "Drabant" when using 100 mg/l CCC and in the varieties "Progress" and "Toyota" when using 1000 mg/l CCC.

The data obtained show that each of the GA_3 doses applied was effective, at least in certain instances, in raising the levels of endogenous growth-stimulating substances, including the auxin (IAA). The fact that GA could increase the auxin level in plant tissues was reported in the literature (Bouillenne—Leyh 1962, Bastin 1967, Andersen—Muir 1969). The present investigation indicated further that changes in the activity of growth-stimulating substances in response to GA_3 depended, at least partly, upon the type of variety used, most probably through the level of native auxin normally possessed by the variety concerned. The observation made by Bouillenne—Leyh (1962) could point in the same direction.

On the other hand, in the present study CCC appeared to lower, in most instances, the level of endogenous growth-stimulating substances, including IAA. This type of effect corresponds with many findings in the literature (Kuraishi—Muir 1963, Norris 1966). The noticed tendency of CCC to behave in certain cases in a reverse manner was similarly met with in the literature (Ivanova 1970). Such exceptional behaviour might be interpreted in terms of changes in the activities of enzymes controlling the auxin catabolism. Two such enzymes: catalase and peroxidase (Pilet—Gaspar 1965) were reported to be inhibited in the leaves of Phaseolus by CCC application (Michniewicz—Stanislawski 1965).

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SECTORIAL DOUBLE PRUNING OF FRUIT TREES

"Use pruning shears and saw as much as necessary, but as little as possible" — is the motto emphasized by de HAAS (1973). As a matter of fact, many experts and researchers have recently criticized the practice of over-pruning, and particularly cutting back, fruit trees (BOUCHÉ-THOMAS 1953, COUTANCEAU 1953, WURGLER—STAEHLIN 1958, FRIEDRICH 1968, ZAHN 1968, HERMANN 1970—71, CLAUS 1976).

The adverse effect of fruit tree pruning is partly due to a permanent disturbance in the ascending and descending sap flow of the pruned organs. In the course of earlier investigations, we demonstrated that both cutting back and thinning result in a one-sided drying-up and eventual transport disorder in the pruned shoot parts. By inducing increased regeneration, especially after cutting back, this sectorial transport disorder influences the development of the shoot system in an undesirable way (BRUNNER 1965, 1968, 1972).

If, however, we reckon with the sectorial transport disorder induced by pruning, it can be made good use of. It was on the basis of this phenomenon that we elaborated the system of sectorial fruit tree pruning (BRUNNER 1970, 1973, 1976), making use of the one-sided inhibition of apical dominance caused by cut-back. Previously, when this phenomenon was left out of consideration, the training of main branches was carried out by pruning to a lower (outside) bud (Fig. 1). Below the one-sided drying-up on the upper side of the slanting branch water-

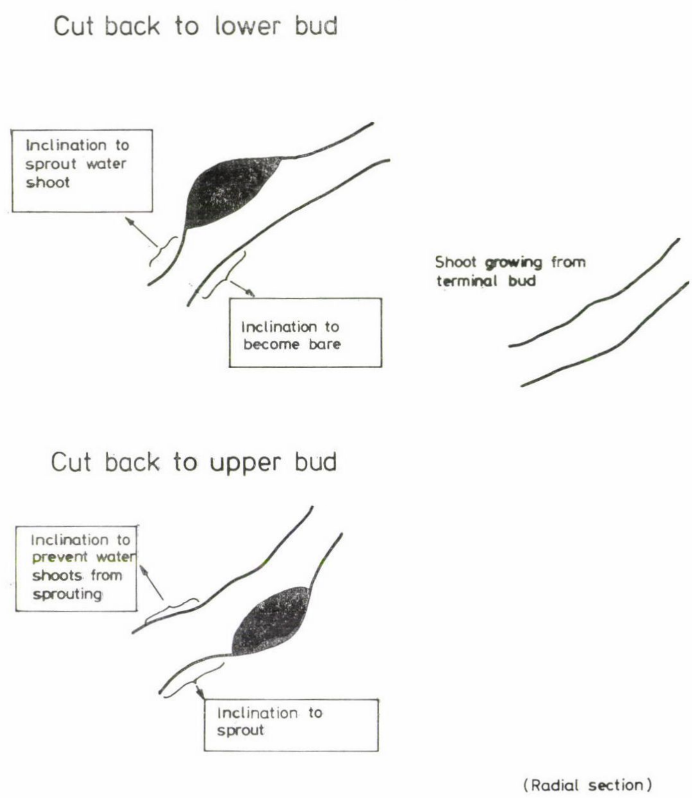

Fig. 1. Effects of cut-back on a slanting branch. (One-sided drying up indicated by hatching)

shoots were thus obtained, which had to be removed. In the system of sectorial fruit tree pruning, on the other hand, the training of main branches is carried out by pruning to an upper (inside) bud. In this case both the one-sided drying-up and the sectorial transport disorder are obtained on the lower, i.e. outer side of the branch, and on the upper side the conditions of transport are undisturbed. In this way the tendency to shoot formation on the upper side of the main branch is decreased, as the dominance of the leader is fully displayed here. At the same time, the inhibition of apical dominance on the lower side, where, for various reasons, the capacity for shoot formation is restricted by nature, does not increase the tendency of the branch to become bare; on the contrary, it enables the lower buds to sprout. Thus, with the method of sectorial pruning, i.e. by cutting back to an upper (inside) bud, the development of water-shoots on the upper, and denudation on the lower side of the branch below the site of pruning can be checked or even eliminated.

According to our investigations, sectorial pruning provides a higher number of slanting or nearly horizontal shoots which are useful from the point of view of production, as it substantially increases the number of shoots on the lower side of the branch, decreases the number of water shoots on the upper side, which must be removed anyway, and at the same time, depending on the crop-year, species and variety, may enhance the lateral growth on the branch compared to that of control branches cut-back to a lower bud.

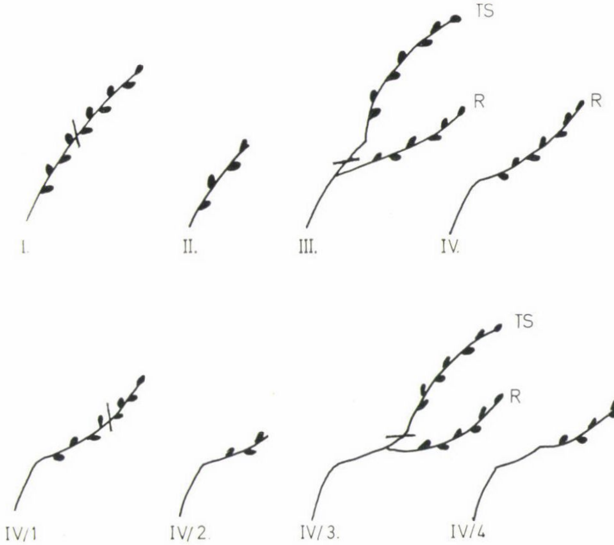

Fig. 2. Phases of sectorial double pruning in two successive years. (Sketch.) First year: I—IV; second year: IV/1—IV/4. I—II: Cutting back of a slanting shoot to an upper (inside) bud in the spring of the current year, or at the end of the summer or in the autumn of the previous year; III—IV: removal of terminal shoot (TS) at the end of the summer or in the autumn of the current year, or in the following spring; IV/1—IV/2: cutting back to an upper (inside) bud of the ramification (R) left after the removal of the terminal shoot (TS) in the spring of the current year, or late summer or autumn of the previous one; IV/3—IV/4: removal of terminal shoot (T S) at the end of the summer or in the autumn of the second year, or in the following spring. (Note: on the lower and lateral surface of the slanting shoot pruned to an upper (inside) bud more than one ramification (R) is naturally produced, but for the sake of clarity only a lower-side ramification (R) is illustrated. — Of the above alternatives the optimum time of pruning should be chosen taking the fruit species and climatic conditions into consideration)

Taking all this into consideration, we have improved our method and elaborated the system of sectorial double pruning of fruit trees. The essential points of this system are as follows:

The shoot which is to be cut, back to an upper (inside) bud should be fixed in the first year either at an angle of 30—45° to the horizontal, or horizontally, unless it takes up one of these positions by nature. This ensures the provision of upper (inside) buds on the upper (inside) surface of a slanting or horizontal branch. Sectorial pruning can then be carried out to an upper (inside) bud. It has previously been emphasized that the terminal shoot obtained from this upper (inside) terminal bud should be tied down to a slanting or horizontal position, the more so because it will be more upright than the one developing from the lower (outside) terminal bud. In the course of sectorial double pruning tying down is avoided, thereby reducing the manual labour input.

According to the system of sectorial double pruning, the upright terminal shoot developing from the upper (inside) bud of the slanting branch should be left untied until autumn or spring (Fig. 2), since in this case pruning to the upper bud was carried out in the spring of the current, or the autumn of the previous year. Thus, the dominance of this erect terminal shoot inhibits the tendency of upper (inside) buds on the slanting or horizontal branch to sprout, to such an extent that even when it is removed in the autumn or next spring, water-sprout formations hardly appear on the upper side of the branch. The small number of generally weak shoots which occasionally develop can be removed during thinning. This reduced capacity for shoot formation on the upper side of the branch is partly due to the fact that shoots which have developed by then on the lower, side attract the flow of nutrients, thus entering into competition with the upper-side growth. For the sake of simplicity the sketch shows only one of the lower-side shoots obtained by pruning to an upper (inside) bud. Next year these favourably situated lower-side shoots, or some of them (sometimes only one: the "terminal") are pruned to an upper (inside) bud again, the erect terminal shoot thus obtained being retained once more until autumn or next spring, so that favourably situated shoots are obtained again on the lower side of the branch without tie-down (Figs 3/A, B, and 4). If the branching below the ter-

Fig. 3/A. Hedelfingen cherry shoot pruned to an upper (inside) bud, with a terminal shoot and ramifications. (Stage III of Fig. 2 — Photo: Migend)

Fig. 3/B. The same as above, after the removal of the terminal shoot. (Stage IV of Fig. 2 — Photo: Migend)

Fig. 4. Hedelfingen cherry shoot pruned to a lower (outside) bud, with a terminal shoot and ramifications resembling watershoots on the upper side, and simultaneous denudation on the lower-side. (Situation corresponding to the model of a slanting branch pruned to a lower bud in Fig. 1 — Photo: Migend)

minal shoot to be removed is too steep, it is cut-back to the next, more favourably sited branching.

Sectorial double pruning is suitable for shaping both the main branches and the bearing shoot system, as proved by experiments performed so far on cherry, sour-cherry and apricot trees (Brunner 1976). Considering, however, that the sectorial transport disorder induced by pruning has been demonstrated in almost all pomiferous and stone-fruit species grown in Hungary (Brunner 1969), sectorial double pruning is expected to give satisfactory results in all arboraceous fruit-bearing plants, particularly for shaping intensive low forms: fruit-hedges and other hedge-like plantations.

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TREND OF GRAIN YIELD IN MAIZE (ZEA MAYS L.) HYBRIDS AS A FUNCTION OF PLANT NUMBER PER UNIT AREA AND SOWING UNIFORMITY

In the course of our investigations we tried to find an answer to the question of how the number of plants per ha, especially at an interval deviating from the previously established optimum, and the uneven distribution of plants within the row, influence the yield in the different hybrids.

There is a large volume of international and Hungarian literature on the correlation between the volume of yield and the plant number per unit area in maize. We are primarily interested in the results of experiments carried out in Hungary under conditions similar to those under which our investigations were made.

Berzsenyi-Janosits (1953) performed spacing experiments with variety hybrids, and I'só (1960) with inbred hybrids. Both authors call attention to the fact that the hybrids require a higher number of plants per unit area compared to open flowering varieties. In a later publication I'só (1962) demonstrated that smaller hybrids with a shorter vegetation period could be spaced closer than larger, later ones. Similar conclusions have been reached by Rossmann—Cook (1966), who say that early hybrids are generally more tolerant to denser sowing than later ones, though there are many exceptions. These statements left the genetic relationship between the hybrids out of consideration. Data on this relationship were published by Sprague (in Bálint 1975). Of the hybrids commercially produced in the United States of America 41.7% was represented by eight inbred lines and their progeny in 1964, while in 1970 six inbred lines and their progeny made up 70.5% of the hybrids. There is thus a high probability of a relationship existing between the different hybrids.

I'só (1969) gives an account of eight single cross hybrids whose plant number per unit area can be safely increased, and demonstrates that combinations including the inbred lines of N6 and 156 can be statistically proved to give higher yields than the others as a response to increased stand density. Ruiz (1966), Earley *et al.* (1966), Russel (1969), Németh (1974) and Győrffy (1976) attribute the favourable yield responses to increased stand density shown by hybrids primarily to their genetic composition.

Literary data on the effect exercised by the uneven distribution of plants within the row on the volume of yield are scarce. Győrffy (1976) refers to farm data obtained during the evaluation of plant growing factors which affect the yield of maize and to the results of experiments carried out in the United States and calls attention to the necessity of uniform sowing. Remussi *et al.* (1974), in a lecture delivered in Bucharest, give an account of an experiment carried out in Argentina on the effect of uneven sowing. According to the results of two years of investigations, the uneven distribution of sunflower plants in the row reduced the yield by 11.7—28.9%, depending on the degree of unevenness. They suggest that the uneven distribution of plants may cause yield reduction in other cultivated plants as well.

In the experiment the following hybrids improved or maintained by the Cereal Research Institute, Szeged were used: A90 × 153R, an early FAO 360 hybrid, state certified in Hungary and Czechoslovakia under the name Keszthelyi SC 360; W64A × Oh43, a medium early FAO 582 hybrid, state certified in Yugoslavia and licensed for commercial production in Hungary as Bc SK 5A; and an A632 × A619-based combination, a medium early FAO 590 hybrid, state certified in Yugoslavia and licensed for commercial production in Hungary under the name Bc 66—25. Our results are based on the data of farm-scale trials and small plot experiments.

Farm-scale trials. Our data were obtained in farm-scale trials carried out in 50—60 farms each year from 1973 to 1975 in various regions of Hungary on maize fields each 2 ha in size. The experimental network covered all the characteristic soil types and the ecologically different maize growing regions of Hungary. Over the average of three years the trial plots showed a lower than average P_2O_5 level and a higher than average K_2O level, and were supplied with 143—160 kg/ha N, 106—130 kg/ha P_2O_5 and 132—165 kg/ha K_2O fertilizer active agent. On average the amount of precipitation was less than the water requirement of maize (during the vegetation period in Hungary) by 113 mm in 1973 and by 21 mm in 1974 and was 50 mm more in 1975. (The water requirement of maize was determined after Berényi 1945). Thus, according to these data the 1973 crop year was dry, while in 1974 and 1975 the precipitation conditions were favourable for the development of maize. If the distribution of precipitation is also taken into consideration it can be stated that 1975 was a particularly good crop year.

During the evaluation the grain yield data obtained in the three years were grouped for each hybrid into optimum plant number intervals and lower than optimum, with 50,000 plants/ha, and an average was calculated for each. In addition the average value of sowing unevenness was determined for each plant number interval. (The optimum plant stand interval for each hybrid previously determined in a small plot plant number experiment was later confirmed by the results of farm-scale trials.)

The 1974 grain yield data were grouped per 1000 plant number interval and according to the value of sowing unevenness for each hybrid. The correlation of the yield averages thus obtained with the number of productive plants per ha (leaving the unevenness of sowing out of consideration), and with the unevenness of sowing (leaving the number of plants out of consideration) were calculated separately. The 1974 data were chosen in studying the correlation because in that year the action of the factors examined was not much disturbed by dry weather, and because the largest number of data on all three hybrids were available for that year.

The 1975 yield data for A90 × 153R were grouped by 5000 plants, and an average value of sowing unevenness was calculated for each group. We chose the 1975 crop year because the precipitation conditions were then the most favourable, and because a sufficient number of data were available for this hybrid. The reliability of the difference between the mean values obtained was checked by the *t*-test, and the square of relative deviation ($s\%^2$) by the F-tests.

Small plot experiment. In 1976, at the Ságvári trial grounds of the Cereal Research Institute, Szeged, the effect of uneven plant distribution in the row on the dry grain yield of A90 × × 153R and the A632 × A619-based hybrid was studied. The results of the one-year small plot experiment were designed to confirm the conclusions drawn from the three-year farm-scale trial. The data obtained by repeating this experiment for several years may serve as a basis for a detailed study of the effect of sowing unevenness.

The experiment was laid out in a random block design with three replications. Each treatment consisted of 10 plants sown in a single row. Of each of the two hybrids a uniform and an uneven plant stand were established by sowing the grains to the same density (5.7 plant s/m^2 in rows spaced at 70 cm) with a seeding apparatus, and thinning the plants at the 6—8 leaf stage. The distance between the plants within a treatment was identical (apart from errors made during implementation) in all the plots. The distance between the plants was measured after thinning, at the 8—10-leaf stage. There was no statistically provable difference in the average plant distance between uniform and uneven treatments in either of the hybrids. The scatter values, however, (at which the treatment was aimed) showed substantial deviations: 2.96 in the uniform and 24.39 in the uneven plant stand of A90 × 153R; 3.10 and 24.32, respectively, in the A632 × A619-based hybrid.

To eliminate the border effect 14 plants were sown per plot and the first and last two plants were left out of the evaluation. To eliminate the effect of the adjacent plot we sowed one row of uniform plant distance on each side of the plot with the hybrid corresponding to the treatment. Harvesting was carried out at 30% grain moisture content. The ears were dried to 14% grain moisture content (later referred to as air-dry) and the grain yield per plant was determined.

The amount of precipitation during the vegetation period was 37.9 mm less than the requirement determined by BERÉNYI (1945). The distribution of rainfall was, however, favourable. During flowering and seed setting, a period particularly important from the point of view of grain production (from one week before to three weeks after male flowering), A90 × 153R received 80.8 mm rain on 11 occasions, while the A632 × A619-based hybrid received 76.0 mm on 10 occasions.

The soil of the experiment was a highly calcareous meadow chernozem with 80 cm of humus and a deep solonetz layer. The pH-value of the humous layer was 8.4. The level of soluble P_2O_5 and K_2O was good. On the trial grounds maize had been grown for 6 years in a monocul-

Table 1

Trend of air-dry grain yield in hybrids examined under farm conditions, as a function of optimum and below-optimum plant densities and uniformity of sowing, on the average of 1973–74–75

Number of plants/ha (1000 plants)	A90×153R			W64A×Oh43			A632×A619		
	sowing uniformity (1-5)	yield average	q/ha deviation	sowing uniformity	yield average	q/ha deviation	sowing uniformity	yield average	q/ha deviation
45–50	—	—	—	2.6	62.8	13.8	—	—	—
50–55	2.3	65.9	4.5	4.2	76.6+		2.8	71.6	8.4
55–60	4.0	70.4+		—	—	—	4.5	80.0+	

Note: The value of sowing uniformity is the average of five categories (1 = uneven, 5 = uniform)

+ On the basis of small plot and farm-scale experiments with an optimum number of plants per ha

ture. The experimental plots were supplied with 400 kg/ha mixed fertilizer active agent at a ratio of 2 : 1 : 1 ($N : P_2O_5 : K_2O$).

The conditions of the experiment (cultivation level, nutrient and water supply of the soil, weed growth, chemical action) did not prevent the unevenness of sowing from making its effect felt.

The grain yield per plant data for the small plot experiment were evaluated by variance analysis. To determine the differences between the relative scatter values (s%) the F-test was used.

This paper is primarily based on the results of farm-scale trials carried out in different parts of Hungary. In spite of the fact that the seed of each hybrid was of identical germination percentage and thousand-grain-weight, and was sown with almost the same viable kernels per ha, and the nutrient level of the plots was also nearly identical, the correlation between plant number and yield was distorted by the effect of sowing unevenness and other factors. Research work is sometimes helped, sometimes hindered by these effects. It is quite possible that we would not have started investigating the effect of uneven sowing if in the small plot experiments the usual optimum curve had been obtained. In the case of identical cultivation levels, the interactions and distorting effects can be traced back mostly to differences in the natural factors. With an adequate number of replications (so that all regions should be properly represented) they can be reduced to a minimum. Under Hungarian conditions, as also proved by the subsequent data, data from at least 15–20 experimental sites are needed to be able to draw conclusions. Otherwise, only data originating from nearly identical growing sites (soil, precipitation) can be taken into consideration.

When studying factors influencing the results of farm-scale trials emphasis should be laid on the precipitation conditions. In Hungary, with an average level of cultivation the precipitation conditions have a decisive influence on the yield of maize. Therefore, if there is a drought during the vegetation period other yield factors (e.g. number of productive plants) are unable to make their effects felt.

Table 1 shows the yield results of the three hybrids examined as a function of plant number and sowing unevenness. (The optimum plant number under the conditions in the different maize growing regions of Hungary was determined for each hybrid in earlier experiments.) It appears from the table that below the optimum plant number the distance between the plants is less uniform than in the case of an optimum plant number. In conformity with our instructions the farms sowed nearly the same number of live germs. Some of them did not come up or died in the seedling stage either because of incorrect cultural practices (unsuitable seed bed, uneven depth of sowing) or for reasons independent of man (soil cracking, damage by soil-borne pathogens, low temperature, damage by game). The death of these plants affected not only the number of plants but also the uniformity of sowing. With a higher than optimum plant number the uneven distribution of plants in the rows was caused by the "bunched" sowing often observed in thick stands.

The effects exerted by the number and uneven distribution of plants on the yield are shown in Table 1. The degree of sowing unevenness and the deviation from the optimum plant number are nearly identical in the three hybrids. In spite of this, according to the three years' results of farm-scale trials, the yield data of A90 × 153R show lower differences than those obtained with the hybrids W64A × Oh43 and A632 × A619.

In order to analyse the effect of the two factors on the volume of yield the yield curves shown in Fig. 1 were calculated and drawn. The shape of the curves, and the variation of the functions, the correlation values and the factors all suggest that in our experiment the uneven distribution of plants in the row had a somewhat higher influence on the grain yield than the number of plants.

According to Fig. 1, there were essential differences between the hybrids as to the correlation of grain yield, plant number and sowing uniformity. The grain yield of A90 × 153R was less sensitive to changes in the plant number and sowing uniformity than the yield data of the hybrids W64A × Oh43 and A632 × A619.

The data of Table 1 and the correlations in Fig. 1 suggest that the increased plant number and the uniform distribution of plants in the row both increase the volume of yield. Thus, if the yield of a hybrid appears to be sensitive to changes in the stand density, it will be sensitive to the unevenness of sowing as well. This supports the theory that uneveny thick or thin rows may have the same effect as plant numbers below and above the optimum.

The results of the small plot experiment are contained in Table 2. The grain yield per plant of A90 × 153R did not decrease in the treatment with uneven plant distance. There is no statistically significant difference between the two treatments. In the case of A632 × A619 the grain yield per plant shows a statistically significant difference between the two treatments. As a response to uneven sowing substantially lower results were obtained. The s%- values serve as an explanation. As for the yield data of A90 × 153R the $s\%^2$- values show no reliable difference between the two treatments, while in the case of A632 × A619 this difference is statistically significant. In the hybrid A90 × 153R the grain yield per plant within the row was not essentially affected by either the uniform or the uneven distribution of plants. In A632 × A619 an essential yield difference was found between uniform rows and the unevenly thick rows of plants. That is what causes the higher standard deviation. The difference between the two hybrids exists in spite of the identical optimum plant number. The results of the small plot experiment confirmed the conclusions drawn from the farm-scale trials.

On the basis of the yield curve for W64A × Oh43 (and according to Fig. 1) the optimum plant number is 50—55,000/ha, while that for A632 × A619 is 55—60,000/ha. The yield responses of the two hybrids to increased plant number and uneven sowing are also nearly identical. The curves for A90 × 153R and A632 × A619 show (in accordance with the earlier results) the same optimum plant number namely, 55—60,000/ha. At the same time, their responses to increased plant number and uneven sowing are different. This seems to suggest that the yield response to increased plant number and uneven sowing is independent from the optimum stand density.

In Fig. 1 there are quadratic and linear correlations between the yield data and plant number of A90 × 153R. The two correlations show nearly the same tendency, but the linear correlation is closer, and, unlike the quadratic correlation, is statistically significant. The linear

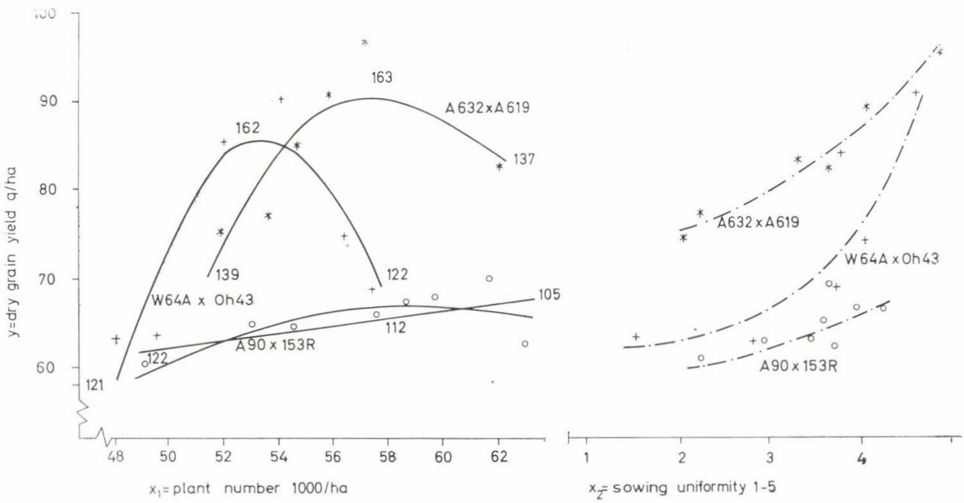

Fig. 1. Correlations between yield, plant number (x_1) and sowing uniformity (x_2) in the hybrids included in the study.

For the quadratic function
A90 × 153R
$y = -165.15 + 7.80x_1 - 0.07x_1^2$
$R = 0.3505$

For W64A × Oh43
$y = -2624.85 + 101.52x_1 - 0.95x_1^2$
$R = 0.9003^*$

For A632 × A619
$y = -1892.89 + 68.45x_1 - 0.59x_1^2$
$R = 0.9206^*$

For the linear function
A90 × 153R
$y = 39.81 + 0.4498x_1$
$R = 0.6398^{**}$

For the quadratic function
A90 × 153R
$y = 53.81 + 2.74x_2 + 0.17x_2^2$
$R = 0.7673$

For W64A × Oh43
$y = 71.02 - 9.80x_2 + 2.89x_2^2$
$R = 0.8735^*$

For A632 × A619
$y = 73.90 - 1.57x_2 + 1.34x_2^2$
$R = 0.9881^{**}$

Note: The values given in the Figure (e.g. 121) show the weight in g of dry grain yield per plant obtained with the plant number plotted on the x_1 axis.

$* = P_{10\%}$
$** = P_{5\%}$

correlation raises the question of whether the optimum plant number determined for this hybrid is really correct, or whether it is the result of having considered only a linear section of the curve. To settle the question, in Table 3 the 1975 yield data were grouped in more plant number categories than in Table 1.

According to the data of Table 3 with the increase in plant number, the distance between the plants in the row becomes more uniform up to the optimum stand density, while above

Table 2

Air-dry grain yield per plant in the case of uniform and uneven plant distance, in a small plot experiment (Szeged, 1976)

Treatment	A90×153R				A632×A619				F (P=5 %)	F (P = 0.1%)
	g/plant	s%	s%²	F	g/plant	s%	s%²	F		
Uniform	181.2	12.6	158.7	1.102	224.9	9.8	96.0	2.733	1.85	2.64
Uneven	191.6	12.0	144.0		185.5	16.2	262.4			
$SD_{5\%}$	—				13.6					
$SD_{0,1\%}$	—				23.5					

Note: The freedom grade (FG = 29) is the same for the two hybrids

Table 3

Air-dry grain yields of A90 × 153R and the scatter of data as a function of plant number and sowing uniformity in the farm-scale trial of 1975

Number of plants/ha (1000 plants)	Sowing uniformity (1–5)	Yield q/ha	s%	s%²	F	FG	F (P = 5%)
40—50	2.9	68.9	20.5	420.3	2.526	15	2.33
50—55	3.7	73.2	18.0	324.0	1.947	11	2.37
55—60⁺	4.2	74.4	12.9	166.4	—	18	—
60—65	3.6	78.0	19.3	372.5	2.239	20	2.19

Note: When calculating the F-values we related the $s\%^2$ values to that of the optimum plant number (marked +)

the optimum plant number it will be uneven again. Thus, together with the change in the plant number, the data of the table show the effect of uneven sowing as well. The yield averages increase even with an above-optimum plant number and growing unevenness. This increase, like the decrease with a plant number below the optimum, is not significant. Deviations from the yield average obtained with an optimum plant number are within a marginal error; they cannot be proved by the *t*-test at a probability level of 95%. The s%- values, however, increase considerably compared to the optimum plant number. Accordingly, this hybrid may give large yields even with a plant number deviating from the optimum, but in this case the risk of production will be considerably higher.

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EFFECTS OF ETHREL AND ZINC ON ABSCISSION AND CELLULASE ACTIVITY IN SOUR CHERRIES

In the course of investigations on the conditions needed for mechanical harvesting, we studied the effect of chemical treatments on fruit abscission, and also the enzymatic background of this effect. In a paper on the morphological changes during fruit abscission LEOPOLD (1971) distinguished an auxin and an ethylene sensitive phase in the abscission zone. The ethylene sensitive phase immediately preceded abscission. In this phase of plant development the activities of cell-wall hydrolysing enzymes are low, and the ethylene-inducing regulators exert their effects by activizing the enzymes (POLLARD—BIGGS 1970, ABELES *et al.* 1971a,b, RASMUSSEN–JONES 1971).

An attempt was made to follow the morphological change and the post-ripening biochemical changes by measuring the fruit removing force and the cellulase (E.C. 3.2.1.4.) activity. Besides measuring the fruit removing force acting on the lower abscission zone (between fruit and stem), we examined the enzyme activity both in the upper abscission zone (between bearing part and stem), and in the lower zone.

The experiment was set up on the sour cherry variety Pándy in the Szigetcsép orchard of the Model Farm of the University of Horticulture in a sweet cherry and sour cherry plantation with medium high trunks and combined crowns established in 1958 at a spacing of 10×10 m. In the orchard the Germersdorfi óriás sweet cherry and Pándy sour cherry varieties were planted in alternate rows. The standard of cultural practices applied was average. The Pándy trees included in the experiment were of medium vegetative and generative capacity.

During the experimental years, the weather prevailing at Szigetcsép was warmer than average. The winter precipitation was low, and a large proportion of the annual precipitation fell in the first half of the vegetation period. Owing to the spring frosts in 1976, the yields of sweet cherry and sour cherry did not exceed 10 kg per tree.

In the Gerőmajor farm unit of the "Magyar—Szovjet Barátság" Co-operative Farm at Kecskemét the plantation included in the experiment was established in 1959 at a spacing of 9×5 m. The sweet cherry varieties "Germersdorfi óriás" and "Hedelfingeni óriás" were the pollen donors for the Pándy sour cherry trees. In 1975 the medium trunk, combined crown sour cherry trees yielded 15—20 kg/tree.

The experiment was set up in six replications. Samples consisting of 50 fruits per treatment were taken from a height of 200 cm on all sides of the trees in an even distribution. The laboratory analyses were carried out at the Department of Fruit Growing and Department of Chemistry of the University of Horticulture.

The chemical treatments were performed with Ethrel at a concentration of 500 and 1000 ppm, with zinc at 50 ppm, and with a combined solution of 500 ppm Ethrel and 50 ppm zinc. The treatments were applied 10—12 days before the expected date of harvest.

The activity of the cellulase enzyme was examined in samples collected on three occasions before the treatment, then on the day of the treatment, and every three days subsequently. The plant parts, excised with a scalpel, were extracted with a 0.1 M phosphate buffer (pH 7.0) containing 0.08 v % cisteine-HCl (ABELES 1969, RATNER *et al.* 1969). The enzyme activity of the solution obtained was determined viscosimetrically. 1.0 ml of the enzyme preparation was incubated at 30°C for 10 minutes with 5.0 ml of a 0.4 v % solution of methyl cellulose ($\bar{M}_w =$ $= 1.3-1.5 \cdot 10^5$) made with a 0.02 M phosphate buffer (pH 6.0). The viscosity of the solution thus obtained was determined by means of an Ostwald-type viscosimeter. The water time of the viscosimeter and the outflow time of 0.5 ml methyl cellulose with 1.0 ml extracting buffer were measured.

The fruit removing force was determined for all fruits collected. We took the fruit between two fingers, affixed a scale to the stem and loaded it gradually until the stem became detached from the fruit. The load gave the value of the force required for abscission (GEISZLER *et al.* 1974).

Of the components the sugar content was determined by the Luff-Schoorl method, the refraction value using a hand refractometer, and the titratable acid content with 0.1 N NaOH in the presence of phenolphthalein.

Studying the effect of Ethrel on abscission in 1974 and 1975, we obtained the results found in Table 1. According to the results, the force required for the separation of stem and fruit greatly decreased under the influence of spraying on 16th June (a week before harvest). The difference found at the beginning between the effects of the two concentrations disappeared by the time mechanical shaking took place. Therefore, in 1976, when the enzymological examinations were carried out, only the 500 ppm concentration was used.

Table 2 contains the average values of relative viscosity and removing force. Solutions containing Ethrel and zinc were applied on 18th June. The relative viscosity data for the lower zone are shown in Fig. 1, those for the upper zone in Fig. 2, while the change in the removing force is illustrated in Fig. 3. Figures 1 and 2 also show the value (4.93) of the combined solution of the extracting buffer and the substrate. At values of relative viscosity lower than this the cellulase

Table 1

Effect of Ethrel treatments on fruit removing force (in ponds) in the lower abscission zone in the case of Pándy sour cherry

Treatment	Measuring date			
	1974*		1975**	
	26th June	2nd July	19th June	24th June
Ethrel 500 ppm	252	66	159	95
Ethrel 1000 ppm	162	79	128	69
Control	559	276	229	164

* Time of spraying: 21st June (Szigetcsép)
** Time of spraying: 16th June (Kecskemét)

depolymerizes its substrate, while at higher values the enzyme acts in the direction of polymerization.

The data show that the enzymatic depolymerization stopped in both abscission zones some ten days before the treatment, and even in the control trees, which followed a natural course of ripening (continuous line in the figures), the enzyme became inhibited. On the sixth day after the treatment the inhibition ceased, then by the ninth day the enzyme activity decreased again. In the lower zone on the third day the Ethrel treatment (broken line in the figure) caused no substantial change in the enzyme activity compared to the control, while under the influence of the combined Ethrel and zinc treatment (dotted line in the figure) and of the zinc treatment (dotting in the figure) a strong inhibition occurred. On the sixth day strong inhibition was observed even in the Ethrel and the combined treatment, while the response to the treatment with zinc was a very strong inhibition. On the ninth day the control and all treatments showed nearly identical enzyme activities. In the upper zone the treatments did not essentially change the enzyme activity compared to the control.

On the third day following the treatment the values of the removing force fell to 58 and 68% of the control as a response to the Ethrel and the combined treatment, respectively. By the sixth day the Ethrel treatment decreased the removing force to 33 and the combined treatment to 39% compared to the control. Until the ninth day the percentages did not essentially change. The zinc treatment did not greatly change the removing force compared to the control (104, 90 and 95%). The treatments did not cause substantial changes in the composition of the fruit.

According to our data, in the course of ripening the cellulase activity decreases, becomes inhibited, then immediately before full ripeness is released from the inhibition for a short time. This is presumably what starts the process leading to the breaking of the vascular bundles (Leopold 1971). The Ethrel treatment probably accelerates this process, so the strong inhibition occurring on the sixth day is probably the analogue of the inhibition appearing on the ninth day in the control trees. The inhibition of the enzyme can be explained as being the inhibitory effect of the reaction product formed in the previous, more active phase (lasting 0—3 days). The data of the zinc and combined treatments suggest that Zn, like Ca (Stösser *et al.* 1969), reinforces the pectin network with an ionic type bond, whereby the removing force is increased and the conditions of diffusion are modified. Zn may, at the same time, exert an activizing effect on the enzyme, so that two simultaneous effects act in opposite directions.

Table 2

Effects of Ethrel and zinc treatments on the relative viscosity proportional to enzyme activity zone (Sziget-

		26th May	11th June	16th June	18th June*
Relative viscosity (η)	Lower zone	3.72	5.02	5.26	6.64
	Upper zone	3.88	5.40	5.10	6.34
Fruit removing force (in ponds)		—	—	—	—

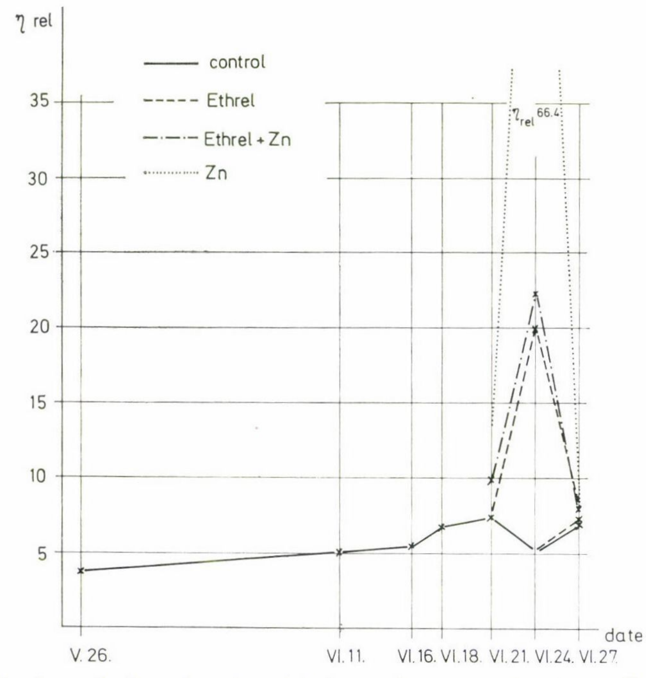

Fig. 1. Changes in the relative viscosity (η), inversely proportional to cellulase activity for the lower abscission zone of Pándy sour cherries as a response to treatments with Ethrel and zinc (Szigetcsép, 1976)

The effect of Ethrel can be observed by the third day, while the zinc, which establishes an ionic bond, increases still more the adherence of stem and fruit. The double role of Zn suggested above is shown in the data of the sixth post-treatment day, when the removing force decreases compared to the control, but the force required for the separation is decreased to a greater extent by the combined and Ethrel treatment than by the zinc treatment.

In addition, an interesting observation was made on the trees included in the combined treatment: the withering and falling of leaves caused by treatments with Ethrel (Grauslund—Stojanov 1971) did not occur.

in the lower and upper abscission zone, and on the fruit removing force with respect to the lower csép, 1976)

21st June				24th June				27th June			
C	E	E + Zn	Zn	C	E	E + Zn	Zn	C	E	E + Zn	Zn
7.26	7.39	9.89	13.7	5.10	20.4	22.4	66.4	6.97	7.99	7.47	7.29
6.49	6.37	5.90	6.12	5.20	5.35	4.95	5.48	5.73	5.68	5.94	5.87
377	219	255	391	297	97	117	268	268	85	105	256

* = date of treatment
C = control
E = Ethrel 500 ppm
Zn = zinc 50 ppm
E + Zn = Ethrel 500 ppm + zinc 50 ppm

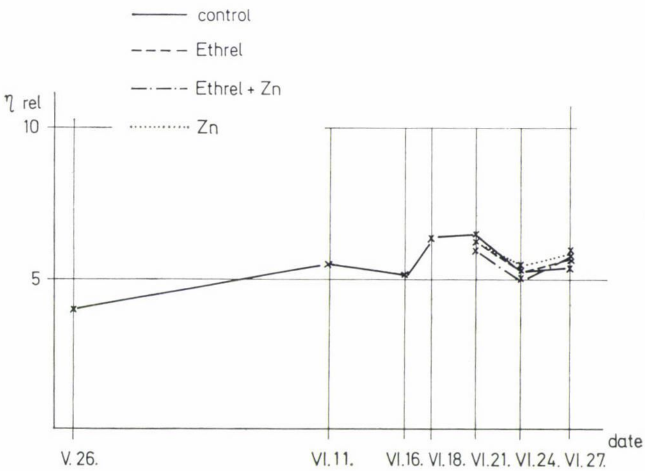

Fig. 2. Changes in the relative viscosity (η), inversely proportional to cellulase activity, for the upper abscission zone of Pándy sour cherries as a response to treatments with Ethrel and zinc (Szigetcsép, 1976)

Table 3

Effect of Ethrel and zinc treatments on changes in the values of components in Pándy sour cherry (Szigetcsép, 1976)

Parameters examined	Treatment			
	C	E	E + Zn	Zn
Refraction, %	17.6	18.2	16.6	17.0
Total sugar (g/l)	107.6	113.6	105.2	105.2
Reducing sugar (g/l)	107.3	113.2	107.6	105.2
Titratable acid (g/l)	32.3	33.6	29.8	32.5

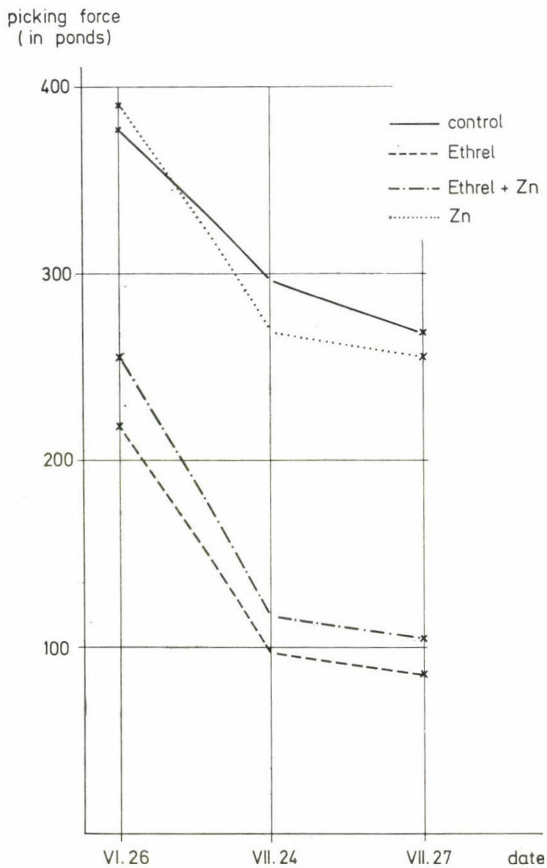

Fig. 3. Changes in the picking force (in ponds) acting on the lower abscission zone of Pándy sour cherries as a response to treatments with Ethrel and zinc (Szigetcsép, 1976)

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NUTRITIONAL AND PHYSIOLOGICAL STUDIES IN JERSEY CATTLE. II. EFFECT OF PLANE OF NUTRITION ON BLOOD PICTURE AND LYSABILITY OF ERYTHROCYTES IN YOUNG JERSEY MALE AND FEMALE CALVES

Blood fulfils a number of essential functions in the biological processes of growth and development. The variations in blood constituents have been considered as a possible criteria of the rate and economy of gain.

Several studies have been conducted to determine specified blood constituents in growing cattle of various weights or at different stages in the life cycle, and attempts have been made to relate these blood constituents to the growth or performance of the animal. MCDONALD *et al.* (1956) measured blood haemoglobin, glucose, urea, amino acid nitrogen, creatinine and uric acid levels in growing Hereford and Angus calves at two body weights. Blood cells of different types have been measured in relation to body weight by BHANNASIRI *et al.* (1961). Furthermore, ARTHAUD *et al.* (1959) measured selected blood constituents and blood cells in relation to the growth of beef cattle.

In chickens, PETROVSKY (1972) proved that a certain relationship exists between egg production and the lysis of chicken erythrocytes by bovine seminal plasma. The correlations between egg production and the lysability of pullet erythrocytes at an early stage of production were high and significant (KHATTAB—EL-ALAMY 1974). Nevertheless, literature is lacking on the relation between the lysis of cattle erythrocytes and economic traits such as daily body weight gain, or rate of growth.

This study was undertaken to evaluate certain blood constituents and the lysability of erythrocytes in yearling Jersey bulls and heifers fed three planes of nutrition, as possible early selection criteria for the rate of growth.

This study was carried out at the Experimental Farm, Faculty of Agriculture, Assiut University, in the years 1974 and 1975. Thirty Jersey calves (15 animals of each sex) of 4 to 6 months of age were used. The planes of nutrition and the system of feeding were described in a previous report by ABDEL-HAFIZ—EL-ALAMY (1976), and are summarized in Table 1.

Blood samples (about 30 ml) were collected from each animal at one year of age and this was repeated 4 times at 45 day intervals for six months. These samples were obtained from the jugular vein in large test tubes containing a well dried anticoagulant of ammonium and potassium oxalate. About 3.0 ml of each blood sample was used for counting the blood cells, for haemoglobin determinations and for lysability tests on the erythrocytes. The remainder was centrifuged at 3000 r.p.m. for 30 minutes and about 10 ml of blood plasma was obtained from each sample.

Red blood corpuscles and white cells were counted using a haemocytometer and haemoglobin was estimated using a haemoglobinometer. The urea-N and total protein were determined in blood plasma. The urea-N was determined gasometrically by Covarsky's method (PETRONKINA 1961), and total protein was determined using a refractometer.

Table 1

Estimated dietary intake of energy (S.V.) and digestible crude protein (D.C.P.) of both male and female Jersey calves from the various feeding regimes

Groups	Starch value (S.V.) kg		D.C.P. g	
	6 – 12 months	12 – 18 months	6 – 12 months	12 – 18 months
I and IV	1.55	2.21	304	436
II and V	1.94	2.71	380	545
III and VI	2.33	3.32	456	654

For estimating the rate of haemolysis of red blood cells (lysability of erythrocytes) the following steps were adopted: 1. 0.1 ml whole blood from each sample was put into a centrifuge tube containing 5 ml seminal plasma from Jersey bulls in saline at a ratio of 1 : 160. 2. The tubes were shaken thoroughly and incubated at 37°C for one hour, followed by centrifugation at 3000 r.p.m. for 10 minutes. 3. The colour density of the lysed erythrocytes was read colorimetrically at a wave length of 520 nm and the solution of each sample was returned to the same tube. 4. The tubes were well stoppered and kept in the freezer overnight. The samples were thawed on the following day, and shaken vigorously for complete haemolysis. 5. The samples were centrifuged again as before, and the density of colour after complete haemolysis was determined colorimetrically using the same wave length. The percentage rate of haemolysis (lysability %) of each sample was calculated as:

$$\text{Rate of haemolysis} = \frac{\text{Optical density of lysed cells after incubation}}{\text{Optical density of completely lysed cells}} \times 100 .$$

The data were transformed to the arcsin $\sqrt{\ }$ proportion and statistically analyzed, according to SNEDECOR (1962).

Simple correlations between lysability and average body weight gain at 12, 15 and 18 months of age were calculated. In spite of the fact that the lysability was determined 5 times in 6 months, the simple correlations were only calculated 3 times in order to give more accuracy in computing the average daily weight gain.

The blood picture of male and female Jersey calves fed three planes of nutrition are shown in Table 2. These results show that, in both sexes, the red blood corpuscles per cubic millimetre increased with the increase in the plane of nutrition. Also, it was slightly higher in males than in females fed at the same feeding level. In this connection, ARTHAUD *et al.* (1959) reported that the erythrocyte count per cubic millimetre ranged from 8.339 to 9.011×10^6, while DUKES (1955) stated that in cattle the average erythrocyte number was 6.3 million per cubic millimetre. He added that the number of erythrocytes varies widely within the species and within the individual (intra-individual variation) and is affected by sex, age, environment, nutrition status, exercise, climate and other factors.

The values of haemoglobin showed nearly the same trend of erythrocytes in respect to the effect of the plane of nutrition, but there was no difference between male and female calves on the general average. The differences in haemoglobin concentration between treatments could be attributed to the differences in digestible crude protein intake. MANSTON *et al.* (1975) found significant differences ($P < 0.05$) between the high and low protein groups in mean concentrations of haemoglobin and packed cell volume. The values of haemoglobin are within the normal range. DUKES (1955) and ARTHAUD *et al.* (1959) reported that haemoglobin g/100 ml ranged from 11.1 to 12.2 in cattle.

On the other hand, white blood cells were not affected by the plane of nutrition and it was of significantly higher concentration in female than in male calves (Table 3). The red blood corpuscles and haemoglobin mostly increased with the increase in age, while the count of white blood cells fluctuated but did not follow the same trend. Statistical analysis (Table 3) showed that the differences in these three characters between periods were significant.

The urea nitrogen concentration was significantly higher in male than in female calves receiving the same level of nutrition. Similar results were reported by BOLING *et al.* (1972), who found that urea nitrogen values were much lower in heifers than those observed in bulls. This may be due to the differences in metabolism between the sexes. Also, as was to be expected, the urea nitrogen concentration was significantly different between the high and low plane of nutrition within the sexes. This is due to the differences in digestible crude protein intake.

Table 2

Blood picture of Jersey male and female calves fed three planes of nutrition

Groups	R.B C.$\times 10^6$/mm^3	White cells$\times 10^3$/mm^3	Haemoglobin g/100 cc	Urea-N mg/100 cc	Total protein g/100 cc
	Mean SE	Mean SE	Mean SE	Mean SE	Mean SE
Males					
I	5.8169 ± 0.1496	10.38 ± 0.613	10.55 ± 0.225	61.72 ± 4.443	6.17 ± 0.210
II	6.2482 ± 0.1756	10.20 ± 0.447	11.11 ± 0.276	62.18 ± 3.500	6.99 ± 0.268
III	6.3533 ± 0.2265	9.84 ± 0.427	11.00 ± 0.198	66.10 ± 1.255	7.04 ± 0.370
Average	6.1714 ± 0.1120	10.07 ± 0.287	10.89 ± 0.142	63.37 ± 2.341	6.73 ± 0.172
Females					
IV	5.7212 ± 0.1868	10.60 ± 0.535	10.84 ± 0.212	47.77 ± 2.687	6.31 ± 0.252
V	6.0972 ± 0.2067	11.68 ± 0.582	10.69 ± 0.215	55.97 ± 4.348	6.92 ± 0.299
VI	6.3768 ± 0.1946	10.32 ± 0.450	11.12 ± 0.172	56.61 ± 3.785	6.60 ± 0.241
Average	6.0651 ± 0.1235	10.87 ± 0.307	10.89 ± 0.116	53.45 ± 2.143	6.61 ± 0.154

Groups I and IV, II and V, and III and VI were fed 100, 125 and 150% of the Ghoneim standard, respectively

Table 3

Statistical analysis for the differences in some blood characters of Jersey male and female calves fed three planes of nutrition

Source of variance	Degrees of freedom	Mean squares of				
		R.B.C.	White blood cells	Haemoglobin	Urea-N	Total protein
Sex	1	0.0060	0.0417*	0.0010	3691.23**	0.573
Treatment	2	0.0272**	0.0153	1.646*	1070.35**	7.296*
Periods	4	0.0137*	0.0506**	28.491**	3295.98**	2.120
Error	142	0.0044	0.0092	0.493	222.52	1.915

Cross *et al.* (1974) also reported a lower ($P < 0.05$) plasma urea nitrogen level in steers receiving a low level of nitrogen as compared to those receiving a higher level of nitrogen.

The results in Table 2 also show that there were significant differences ($P < 0.05$) in plasma total protein between the three treatments in both sexes, animals receiving the lower plane of nutrition having lower concentrations of plasma protein than those receiving the higher level. On the other hand, total plasma protein concentrations were slightly higher in male than in female calves, especially when they were fed the higher level of nutrition. However, these differences were not statistically significant. Similarly Boling *et al.* (1972) reported that plasma protein in heifers was slightly lower than the values observed in bulls.

It is concluded from the results in this paper that the concentration of urea in blood plasma can be a sensitive indicator of the current intake of digestible crude protein and that the plasma haemoglobin concentration can be a useful index of protein status in yearling calves.

Concerning the lysability of erythrocytes, the results in Table 4 indicated that the seminal plasma of Jersey bulls (used as a titre) caused slightly, but insignificantly higher general averages of haemolysis in the erythrocytes of Jersey female calves than in those of the males. However, the rate of haemolysis was not affected by the plane of nutrition in the female groups and slightly decreased with the increase in the level of food intake in the male groups. Khattab—El-Alamy (1974) reported that cock erythrocytes were more resistant to lysis than those of pullets.

Table 4

Lysability of Jersey erythrocytes as affected by sex, age and plane of nutrition

Stage	Lysis %					
	100% Sta.		125% Sta.		150% Sta.	
	Mean	SE	Mean	SE	Mean	SE
Males						
(1) 12.0 months	35.34	± 13.79	39.46	± 14.02	45.87	± 14.00
(2) 13.5 ,,	84.00	± 12.37	74.44	± 9.66	77.39	± 11.05
(3) 15.0 ,,	27.15	± 5.80	26.84	± 4.06	27.03	± 5.05
(4) 16.5 ,,	56.08	± 9.41	66.40	± 4.80	58.12	± 3.30
(5) 18.0 ,,	55.52	± 5.94	38.67	± 10.97	35.93	± 5.51
Average	51.62	± 5.72	49.16	± 5.33	48.87	± 3.02
Females						
(1) 12.0 months	61.64	± 5.75	56.57	± 10.86	66.38	± 10.31
(2) 13.5 ,,	72.87	± 7.30	57.92	± 11.50	53.28	± 11.16
(3) 15.0 ,,	33.19	± 8.08	28.67	± 8.25	31.12	± 7.92
(4) 16.5 ,,	61.45	± 7.77	65.19	± 3.88	65.54	± 6.28
(5) 18.0 ,,	34.45	± 4.83	45.51	± 8.25	39.63	± 10.62
Average	52.72	± 4.30	50.77	± 4.50	51.19	± 4.87

Sta. = Ghoneim standard (1950)

Table 5

Analysis of variance of the differences in lysability due to sex, age and plane of nutrition

Source of variance	d.f.	Mean squares of rate of haemolysis
Sex	1	5.47
Treatment	2	37.00
Periods	4	3606.99**
Error	142	199.18

** Significant ($P < 0.01$)

From another point of view, the effect of age or stage of growth in both sexes on the rate of haemolysis (lysability %) was clear and the differences were statistically highly significant (Table 5). Significant age differences in the lysability of chicken erythrocytes were found by PETROVSKY (1972) and KHATTAB—EL-ALAMY (1974).

The relationship between daily weight gain and lysability showed that in males there was a negative correlation at 12 months of age ($r = -0.44$). This may be due to changes in the hormonal balance accompanying the stage of puberty in males. At this stage, there was a relatively higher body weight gain coupled with a relatively lower rate of lysability. On the other hand, these correlations were positive and non-significant at 15 and 18 months of age ($r = 0.22$ and 0.31, respectively). In females, these correlations were positive and significant only at 18 months of age ($r = 0.17$, 0.24 and 0.56 at 12, 15 and 18 months, respectively). These differences indicate that male erythrocytes are more resistant to lysis than those of females and this may be due to the difference in the level of sex hormones in the blood of the animals.

In general, the present data showed that the lysability average in females when they gained less than 0.21 kg/day was 36.77%, and when they gained 0.21 kg or more the average was 50.49%. The lysability average in males which gained less than 0.41 kg/day was 40.51% and in those which gained 0.41 kg/day or more the average was 28.72%. This finding indicated that males with a relatively higher gain showed lower lysability while females with a relatively higher body weight gain showed the reverse.

From a practical point of view, the present work could be considered as a preliminary step towards testing the rate of haemolysis (lysability %) as an indicator for early selection, especially in male calves, for higher body weight gain. A large number of young animals of both sexes must be included in the next experimental study for a more accurate evaluation of this relationship.

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EFFECT OF DIFFERENT LEVELS OF SODIUM CHLORIDE ON THE GROWTH AND MINERAL COMPOSITION OF SOME WHEAT VARIETIES

Wheat is one of the main crops that is cultivated in many countries of the arid and semiarid regions. Many authors reported that plants which are highly salt tolerant can effectively control salt levels within the plant by partitioning the salt to specialized leaf tissue or by retention of excess salt in the roots (WALLACE *et al.* 1973). In this respect, wheat plants are moderately salt tolerant. Under Egyptian conditions, agricultural expansion depends on cultivating large areas of the western desert, while a considerable area of the cultivated soil is salt-affected soil. However, the control of the wheat plant over salinity varies between the different stages of growth, as reported by BERNSTEIN—HAYWARD (1958). Since the germination and seedling stages are the most sensitive stages in this respect, they are negatively affected by high concentrations of soluble salts in the root medium, as reported by MALEWALL—PALEWALL (1967).

The wide-spread cultivation of Mexican wheats under Egyptian soil and environmental conditions requires a great deal of information in order to retain their high productivity through intensive and more specific investigations. The purpose of this study was to determine some growth characteristics and the mineral composition of five wheat varieties as affected by different levels of sodium chloride, from the point of view that such a study is important for securing their high productivity in Egypt.

A pot experiment was conducted at the beginning of October 1976 in the greenhouse of the soil department, Faculty of Agriculture, El-Minia. The soil used in this study was brown alluvium, non saline and of clay loam texture from the surface layer of the experimental farm of the El-Minia Faculty of Agriculture. The soil sample was air-dried and sieved through a 2-mm sieve. Representative soil samples were analyzed to determine pH (1 : 2.5), E.C. m mhos/cm, organic matter %, $CaCO_3$%, C.E.C. me/100 g soil and exchangeable cations Na—K—Ca—Mg me/100 g soil and a mechanical analysis was made. The physical and chemical characteristics of the soil are given in Table 1.

Plastic pots 12 cm in diameter were filled with 250 g of the sieved soil sample. The wheat varieties under investigation were Giza 156 and four Mexican varieties, namely, Gori 69, Chenab 70, Super X and Maxback 69. A completely randomized design with 6 replicates and five treatments consisting of different levels of NaCl, together with a control. 20 me/l $CaCl_2$ was applied with all solutions receiving NaCl (10, 50, 150, 250 and 400 me/l NaCl). The highest level is more concentrated than sea water. In each pot twenty five seeds from the wheat varieties studied were sown at a depth of 1 cm. All the pots received 125 ml of NaCl solution, except for the control which received distilled water only, thus reaching the field capacity. Every day the pots were irrigated with distilled water to their field capacity. After 21 days the seedlings were harvested and some growth characteristics, i.e. the number of seedlings per pot, fresh weight per seedling, dry weight per seedling height and the number of leaves per seedling, were recorded. Representative samples of the ground dry matter were wet ashed using H_2SO_4 and H_2O_2. The digest was finally used for the chemical determination of N, P, Cl, Na, K, Ca and Mg as criteria for treatment evaluation. Total nitrogen was determined after Jackson (1967), P was determined colorimetrically after King (1951), Na and K were determined using the flame photometer, Ca and Mg were determined by precipitation according to LEPPER (1950) and Cl was determined titrimetrically using silver nitrate solution (PIPER 1950). The data obtained were statistically analyzed as described by SNEDECOR (1956).

Growth characteristics. The values of some growth characteristics of the wheat varieties studied as affected by different levels of NaCl are presented in Table 2. The results revealed a significant decrease in the number of seedlings per pot especially in treatments above 50 me/l NaCl. Of the Mexican varieties, Chenab 70 seems to be the most salt tolerant and Super X the most salt sensitive variety. No germination was obtained in any of the varieties tested after the 400 me/l NaCl treatment and in Super X no germination was obtained after the 250 me/l NaCl treatment either. This many be due to the explanation made by MALEWALL—PALEWALL (1967), who reported that salt tolerance at the seedling stage varied between the different wheat varieties and seems to be due to the differing ability of the varieties to adapt to the saline conditions. The data obtained showed that fresh and dry weights per seedling increased in the 10 me/l NaCl treatment compared to the control in the varieties Giza 156 and Gori 69, but the increase was slight and not significant. The afore-mentioned characteristics decreased significantly above 10 me/l NaCl. In the other varieties all the NaCl treatments caused a significant decrease in these characteristics as compared with the control. Also, the seedling height and the number of leaves per seedling decreased significantly in treatments above 10 me/l NaCl.

Table 1

*Physical and chemical characteristics of the soil**

pH 1.2.5	E.C. mmhos/cm	O.M. %	$CaCO_3$ %	C.E C. me/100 g soil	Exchangeable cations me/100 g soil				Mechanical analysis				Texture grade
					Na^+	K^+	Ca^{++}	Mg^{++}	C. sand %	F. sand %	Silt %	Clay %	
7.95	2.23	1.68	2.04	40.2	1.89	2.16	27.01	8.94	1.24	29.1	31.88	34.89	Clay loam

* Determined as described by WALKLEY and BLACK (1947), PIPER and JACKSON (1967)

Table 2

The effect of different levels of NaCl on some growth characteristics of five wheat varieties

NaCl me/l	Number of seedlings/pot	Fresh weight/seedling, mg	Dry weight/seedling, mg	Dry matter, %	Seedling weight, cm	Number of leaves per seedling
Giza 156						
0	18.3	255.8	28.2	10.94	24.12	2.68
10	18.0	264.0	30.2	11.44	25.27	2.64
50	17.3	220.8	26.0	11.78	22.42	2.63
150	17.0	130.0	18.8	14.46	15.66	2.28
250	16.0	664.0	13.5	21.09	8.22	2.00
400	—	—	—	—	—	—
LSD 5%	0.9	11.8	1.91		1.64	0.03
Gori 69						
0	22.5	226.8	26.3	11.11	19.39	2.99
10	22.5	238.3	27.3	11.88	19.80	2.99
50	19.8	194.5	24.5	12.60	17.66	2.93
150	19.0	142.3	23.0	16.16	14.77	2.40
250	4.8	73.5	18.4	25.03	6.99	1.85
400	—	—	—	—	—	—
LSD 5%	1.1	12.1	1.75		1.35	0.05
Chenab 70						
0	18.8	249.5	27.5	11.02	21.56	2.99
10	21.8	223.0	24.5	10.99	21.15	2.99
50	22.3	200.0	23.8	11.90	19.99	2.98
150	17.5	145.3	21.3	14.59	15.01	2.93
250	10.3	66.0	11.5	17.42	7.25	2.11
400	—	—	—	—	—	—
LSD 5%	1.2	9.8	1.48		1.12	0.03
Super X						
0	22.3	198.0	21.5	10.86	21.32	2.59
10	17.8	178.3	21.0	11.77	20.71	2.55
50	16.3	151.5	19.5	12.87	19.71	2.53
150	11.3	82.5	15.0	18.18	10.64	2.24
250	—	—	—	—	—	—
400	—	—	—	—	—	—
LSD 5%	1.2	11.6	1.42		1.43	0.06
Maxback 69						
0	22.0	214.5	23.5	10.95	24.24	2.82
10	21.0	210.4	24.3	11.55	24.20	2.77
50	21.0	164.5	20.8	12.64	22.45	2.62
150	11.5	98.5	15.5	15.74	13.72	2.34
250	8.0	47.5	9.3	19.58	6.17	2.04
400	—	—	—	—	—	—
LSD 5%	1.3	10.7	1.63		1.68	0.08
LSD of interaction variety × treatment	2.1	18.2	2.80		2.35	0.11

Table 3

The effect of different levels of NaCl on the mineral composition % of five wheat varieties (Seedling stage)

NaCl	N	P	Cl %	Na	K	Ca	Mg
Giza 156							
0	2.38	0.36	1.42	0.27	4.16	0.39	0.27
10	2.31	0.34	2.74	0.72	3.62	0.67	0.23
50	1.84	0.19	8.58	1.07	3.18	0.31	0.12
150	1.73	0.19	10.22	1.34	2.96	0.30	0.11
250	1.69	0.18	14.31	1.58	2.83	0.30	0.11
400	—	—	—	—	—	—	—
LSD 5%	0.21	0.08	1.03	0.21	0.42	0.16	0.03
Cori 69							
0	2.81	0.39	1.28	0.19	4.28	0.43	0.29
10	2.76	0.38	2.68	0.61	3.70	0.78	0.25
50	2.23	0.25	8.40	0.98	3.31	0.36	0.15
150	1.82	0.19	10.75	1.30	2.99	0.33	0.13
250	1.72	0.19	12.18	1.61	2.91	0.36	0.12
400	—	—	—	—	—	—	—
LSD 5%	0.18	0.11	1.15	0.13	0.41	0.13	0.08
Chenab 70							
0	2.46	0.39	1.30	0.22	4.26	0.42	0.29
10	2.19	0.35	2.77	0.78	3.45	0.81	0.24
50	1.80	0.21	4.43	0.89	3.11	0.35	0.12
150	1.72	0.19	9.86	1.21	2.71	0.33	0.11
250	1.65	0.18	13.71	1.59	2.69	0.30	0.11
400	—	—	—	—	—	—	—
LSD 5%	0.25	0.09	1.40	0.24	0.51	0.15	0.09
Super X							
0	2.36	0.37	1.29	0.20	4.22	0.40	0.28
10	2.30	0.33	2.89	0.71	3.38	0.77	0.22
50	1.81	0.18	9.65	1.61	2.93	0.38	0.12
150	1.56	0.18	11.93	1.62	2.83	0.30	0.10
250	—	—	—	—	—	—	—
400	—	—	—	—	—	—	—
LSD 5%	0.27	0.10	1.56	0.27	0.58	0.18	0.07
Maxback 69							
0	2.46	0.37	1.30	0.22	4.21	0.39	0.28
10	2.32	0.35	2.83	0.62	3.39	0.72	0.24
50	1.95	0.20	8.42	0.92	3.09	0.36	0.12
150	1.83	0.19	11.80	1.31	2.73	0.30	0.11
250	1.60	0.19	13.08	1.60	2.80	0.32	0.11
400	—	—	—	—	—	—	—
LSD 5%	0.24	0.12	1.09	0.23	0.60	0.14	0.08
LSD of interaction variety × treatment 5%	0.31	0.19	2.09	0.42	1.01	0.28	0.12

The decrease in the growth characteristics of wheat seedlings due to the increase of salt concentration in the root medium is reported to be the result of an increase in the rate of respiration during germination with increasing salt concentration. As reported by KLEINKOPF *et al.* (1975), the observed decrease is probably a result of the increased energy expenditure required for salt pumping and the maintenance of tissue integrity. NIEMAN (1956) reported that Cl stimulates oxygen consumption by plant roots and activates cytochrome oxidase. HONDA—GREGORY (1958) noted that Cl activates the oxidation of cytochrome C.

Generally, the results obtained are in good agreement with those obtained by HAYWARD—LONG (1943) and GAUCH—WADLEIGH (1944), who found that the growth and dry matter content of tomato and bean plants decreased with increasing sodium salt concentration in the root medium. BERNSTEIN—PEARSON (1956) reported that high sodium concentrations in the root medium increase its accumulation in the root tissues, which negatively affects plant growth due to the decrease in the absorption and translocation of water in these plants.

On the other hand, the data show that the dry matter % of the wheat seedlings increased with increasing NaCl concentration. This may be due to the fact that meristem and young cells are capable of storing relatively large quantities of minerals through accumulation, and that accumulation increases relatively with increasing salt concentration in the root medium.

Regarding the interaction of the two factorial effects, it is obvious that the results show substantial differences between the varieties tested.

Mineral composition. The mineral composition of wheat seedlings grown at different levels of NaCl is given in Table 3. The results obtained reveal that sodium chloride tends to decrease the K, Ca and Mg levels in wheat seedlings through antagonistic phenomena, as reported by LARSON—PIERRE (1953).

It is worth mentioning that the highest Ca concentration was recorded in the 10 me/l NaCl treatment. This is due to the inbalance caused through the addition of 20 me/l $CaCl_2$. No $CaCl_2$ was added to the control, so the highest proportion of Ca to Na was found in the 10 me/l NaCl treatment.

The N and P content of wheat seedlings decreased significantly with increasing NaCl concentration. On the other hand, the Na and Cl content of wheat seedlings increased significantly with increasing NaCl concentration. However, the increase in Cl content was much higher than the increase in Na content. This may be due to the ease of movement and translocation of Cl (WOOLLEY *et al.* 1958, MENGEL 1960 and SCHMALLFUSS—REINICKE 1960), while the translocation of Na from the root to the shoot is very slow (WYBENGA 1957).

However, it seems from the results obtained that the variation in salt tolerance between the wheat varieties tested, specially the imported Mexican varieties, may be helpful in securing their high productivity in Egypt.

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CORRELATION STUDIES AND THE APPLICATION OF DISCRIMINANT FUNCTION SELECTION IN INDIAN MUSTARD

A knowledge of the correlation between yield and its components is of great value in planning and evaluating breeding procedures for the improvement of yield. Information on path coefficient analysis is important, as it provides a means of untangling the direct and indirect contribution of various factors in building up a complex correlation. The use of a discriminant function in plants has been provided by SMITH (1936), using data on wheat for the selection of a character or characters which would give maximum genetic advance through selection. This paper reports on the investigation of phenotypic, genotypic and environmental correlation in parents and F_1s, the direct and indirect effects of the component characters on the yield, and the construction of a suitable selection index in Indian mustard (*Brassica juncea* L Czern and Coss).

The material for the investigation consisted of six parental lines of *B. juncea* L Czern and Coss, namely, Varuna KB 2, Laha 101, Rai 5, Rai 7 and Rai Monipuri and all their possible F_1 hybrids without reciprocals. Each population was grown in a single row plot according to a randomized complete block design with three replications. Ten randomly selected plants from each row of a replication were used to record data on the following characters: (1) days to heading, (2) plant height at heading (cm), (3) harvesting date, (4) plant height at harvest (cm), (5) siliqua length, (6) siliqua number/plant, (7) seed number/siliqua, (8) primary branch number, (9) secondary branch number, (10) thousand seed weight, (g) and (11) seed yield/plant (g).

Phenotypic and genotypic correlation coefficients were calculated from variance and covariance analysis (MILLER *et al.* 1958). The path-coefficients were analysed using WRIGHT's (1921) path- coefficients, as illustrated by DEWEY—LU (1959), at the phenotypic and genotypic levels for the parental and F_1 generations, separately. Using different character combinations, discriminant functions were constructed according to the procedure given by SMITH (1936).

The phenotypic, genotypic and environmental correlation coefficients between the characters studied in the parental and F_1 generations separately are given in Tables 1 and 2. The phenotypic and genotypic correlations between seed yield/plant and primary branch number were highly significant in both generations. The correlations of siliqua number and secondary branch number with seed yield/plant were positive and significant only in the F_1. Seed yield/ /plant showed a non-significant correlation with siliqua length and thousand seed weight. Plant height at harvest and days to heading showed significant negative associations with seed yield/plant. The association between seed number/siliqua and seed yield/plant was non-significant. Plant height at heading showed a non-significant association with seed yield/plant. Primary branch number had a highly positive correlation with secondary branch number at the

Table 1

Phenotypic (r_p), genotypic (r_g) and environmental (r_e) correlation coefficients between yield, and yield components of parents (upper diagonal) and F_1 (lower diagonal)

		Siliqua length	Siliqua number/plant	Primary branch number	Secondary branch number	Thousand seed weight	Seed yield/plant
Siliqua length	r_p		—0.43	—0.60	—0.86*	—0.04	0.36
	r_g		—0.45	—0.62	—0.88	0.30	0.37
	r_e		—0.02	0.03	—0.44	—0.47	0.03
Siliqua number/plant	r_p	—0.31		0.80	0.71	0.10	0.70
	r_g	—0.31		0.80	0.71	0.66	0.69
	r_e	—0.33		0.14	0.51	—0.42	0.40
Primary branch number	r_p	—0.65**	0.39		0.88*	—0.20	0.89*
	r_g	—0.72	0.41		0.89	—0.91	0.90
	r_e	0.12	0.37		—0.20	0.14	—0.34
Secondary branch number	r_p	—0.57*	0.26	0.68**		—0.11	0.72
	r_g	—0.63	0.28	0.70		—0.30	0.74
	r_e	0.06	—0.14	0.15		—0.34	0.51
Thousand seed weight	r_p	—0.16	0.16	0.23	0.48		0.46
	r_g	—0.17	0.17	0.24	0.49		0.47
	r_e	—0.04	—0.18	—0.12	0.13		—0.68
Seed yield/plant	r_p	0.30	0.73**	0.74**	0.63*	0.35	
	r_g	0.33	0.71	0.75	0.63	0.40	
	r_e	0.08	—0.01	—0.02	—0.46	—0.20	

*, ** Significant at 5% and 1% level respectively in all tables

Table 2

Phenotypic (r_p), genotypic (r_g) and environmental (r_e) correlation coefficnets between yield and non-yield components of parents (upper diagonal) and F_1 (lower diagonal)

		Days to heading	Plant height at heading	Plant height at harvest	Harvesting date	Seed number/siliqua	Seed yield/plant
Days to heading	r_p		0.91*	0.70	0.48	—0.51	—0.58
	r_g		0.92	0.71	0.50	—0.54	—0.62
	r_e		0.45	0.20	0.13	0.57	0.29
Plant height at heading	r_p	0.82**		0.89*	0.47	—0.36	—0.75
	r_g	0.84		0.90	0.48	—0.37	—0.78
	r_e	0.10		0.60	0.15	0.50	0.14
Plant height at harvest	r_p	0.66**	0.77**		0.66	—0.45	—0.84*
	r_g	0.67	0.78		0.70	—0.45	—0.86
	r_e	—0.03	0.13		—0.03	0.11	0.27
Harvesting date	r_p	0.42	0.34	0.49		—0.88*	—0.60
	r_g	0.43	0.35	0.50		—0.92	—0.66
	r_e	0.10	0.03	0.37		0.36	0.78
Seed number/siliqua	r_p	—0.21	—0.25	0.03	—0.50		0.33
	r_g	—0.21	—0.25	0.03	—0.53		0.34
	r_e	—0.14	—0.30	—0.11	0.09		0.08
Seed yield/plant	r_p	—0.52*	—0.49	—0.63*	—0.23	0.14	
	r_g	—0.54	—0.50	—0.64	—0.25	0.14	
	r_e	0.22	0.03	—0.02	0.19	0.23	

phenotypic and genotypic levels. Siliqua length showed a significant negative association with secondary branch number, and in the F_1 with primary branch number only. The genotypic and phenotypic correlation coefficients of days to heading with plant height at heading were positive and significant, but with height at harvest, it was significant in the F_1 only. Plant height at heading showed a significant correlation with plant height at harvest both at the phenotypic and genotypic levels.

A path coefficient analysis, which measures the direct as well as the indirect effects of one variable through another on the end-products, was worked out in the parental and F_1 generations at the phenotypic and genotypic levels. The direct and indirect effects of the component characters studied on seed yield/plant are presented in Tables 3 and 4.

The partitioning of the correlation between siliqua length and seed yield/plant indicated that the direct effect of siliqua length was positive but low. The positive correlation was the result of the positive indirect effects of primary branch number in both generations and the siliqua number/plant in the parent.

The positive correlation between siliqua number/plant and the seed yield was the result of the positive direct effect of this character. Secondary branch number showed a high indirect effect in the parents but siliqua length and the primary branch number showed negative indirect effects.

Table 3

Path coefficient analysis of seed yield vs. some components of yield

Pathways of association	Parent		F_1	
	Phenotypic	Genotypic	Phenotypic	Genotypic
Yield vs. siliqua length				
Direct effect	0.124	0.136	0.091	0.047
Indirect effect via:				
Siliqua number/plant	0.515	0.540	−0.176	−0.182
Primary branch number	1.121	1.121	0.383	0.467
Secondary branch number	−0.938	−0.937	0.001	−0.012
Thousand seed weight	−0.464	−0.484	0.008	0.009
Yield vs. siliqua number/plant				
Direct effect	1.191	1.191	1.574	1.589
Indirect effect via:				
Siliqua length	−0.300	−0.394	−0.428	−0.514
Primary branch number	−0.883	−0.797	−0.236	−0.260
Secondary branch number	0.777	0.778	0.006	0.005
Thousand seed weight	0.010	0.010	−0.188	−0.108
Yield vs. primary branch number				
Direct effect	1.869	1.869	0.893	0.652
Indirect effect via:				
Siliqua length	−0.416	−0.545	−0.059	−0.433
Siliqua number/plant	−0.945	−0.945	−0.318	0.014
Secondary branch number	0.970	0.973	0.229	0.736
Thousand seed weight	−0.582	−0.455	−0.012	−0.223
Yield vs. secondary branch number				
Direct effect	1.097	1.097	0.752	0.980
Indirect effect via:				
Siliqua length	−0.594	−0.767	−0.052	−0.029
Siliqua number/plant	0.844	0.876	0.365	0.163
Primary branch number	−0.620	−0.452	−0.404	−0.457
Thousand seed weight	−0.011	−0.011	−0.025	−0.028
Yield vs. thousand seed weight				
Direct effect	0.109	0.109	−0.053	−0.057
Indirect effect via:				
Siliqua length	−0.030	−0.030	−0.014	−0.008
Siliqua number/plant	0.116	0.116	0.558	0.563
Primary branch number	0.383	0.383	−0.135	−0.156
Secondary branch number	−0.118	−0.110	−0.001	0.049

Table 4

Path coefficient analysis of seed yield vs. non-yield components

Pathways of association	Parent		F_1	
	Phenotypic	Genotypic	Phenotypic	Genotypic
Yield vs. days to heading				
Direct effect	0.217	1.916	—0.526	—0.659
Indirect effect via:				
Plant height at heading	—0.659	—5.906	0.673	0.896
Plant height at harvest	—0.029	4.315	—0.796	—0.948
Harvesting date	—0.406	—3.370	0.242	0.313
Seed number/siliqua	0.297	2.424	—0.115	—0.143
Yield vs. plant height at heading				
Direct effect	0.726	0.387	0.819	1.071
Indirect effect via:				
Days to heading	0.197	1.772	—0.432	—0.551
Plant height at harvest	—0.517	—0.423	—0.934	—1.102
Harvesting date	—1.397	—3.251	0.196	0.254
Seed number/siliqua	0.211	0.666	—0.140	—0.173
Yield vs. plant height at harvest				
Direct effect	—0.042	—1.053	—1.212	—1i412
Indirect effect via:				
Days to heading	0.151	2.366	—0.345	—0.442
Plant height at heading	—0.648	—0.722	0.631	0.836
Harvesting date	—0.559	—4.598	0.283	0.359
Seed number/siliqua	0.263	2.041	0.011	0.016
Yield vs. harvesting date				
Direct effect	—0.851	—0.790	0.582	0.725
Indirect effect via:				
Days to heading	0.104	0.951	—0.219	—0.284
Plant height at heading	—0.339	—3.058	0.275	0.375
Plant height at harvest	—0.027	0.099	—0.589	—0.699
Seed number/siliqua	0.516	2.133	—0.282	—0.366
Yield vs. seed number/siliqua				
Direct effect	0.587	0.492	0.559	0.690
Indirect effect via:				
Days to heading	—0.110	—2.734	0.108	0.137
Plant height at heading	—1.061	—2.369	—0.206	—0.268
Plant height at harvest	0.018	2.750	—0.025	—0.033
Harvesting date	0.748	2.246	—0.293	—0.385

A high positive direct effect of primary branch number and secondary branch number on seed yield/plant were noticed in both generations. Among the component characters, for primary branch number, the secondary branch number showed a high positive indirect effect, whereas for secondary branch number an indirect positive contribution was found via siliqua number/ /plant. The indirect effects of other characters were negative.

The direct effect of thousand seed weight was positive in the parent and negative in the F_1. Among the component characters siliqua number/plant showed a high positive indirect effect in both generations and primary branch number in the parental generation only. This indicated that the positive association between thousand seed weight and the seed yield/plant was due to high positive indirect effect of primary branch number in the F_1 and both primary branch number and the siliqua number/plant in the parent.

The direct effect of seed number/siliqua was positive. The indirect effects via days to heading, plant height at harvest and harvesting date were inconsistent over two generations.

Selection indices for seed yield/plant and the yield components of each generation were constructed to identify the character or characters which may be useful during selection breeding for higher yield. The various selection indices and expected gain as a percentage over straight selection for seed yield are presented in Table 5. In most of the cases, the values were consistent over generations. Individually, seed yield/plant showed the highest expected gain of 25.04 and 34.11% for the parental and F_1 generations, respectively. Among the component characters, siliqua number/plant and primary branch number indicated high positive gains. When a combination of two or more characters with seed yield/plant as an independent character was studied in an index, the expected gains were high. The maximum gains of 46.19 and 49.36% for the parental and F_1 generations, respectively, were obtained when all six characters were included in the selection index. Among the components, siliqua number/plant and seed yield, primary branch number and seed yield and siliqua number/plant, primary branch number and seed yield gave good expected gains.

Information on the interrelationship between the yield and its components and also between these components themselves is important for the effective selection breeding of evolving high yielding lines. In the present investigation, the component characters which showed a significant association with seed yield were siliqua number/plant and primary and secondary branch number, both at the phenotypic and genotypic levels. This indicated that these three components were genetically related with seed yield/plant more than the other yield components. Moreover, these three characters showed highly positive direct effects on the seed yield, indicating that the characters themselves were responsible for a high correlation with seed yield. Thus, selection on the basis of any of these characters is expected to give a desired correlated response. PAUL *et al.* (1976) also reported a high correlation between siliqua number/plant and seed yield in the same crop.

In selection breeding experiments, a breeder generally faces the problem of selecting a component character or a number of components which will give maximum genetic advance through selection. In this respect, a number of workers have applied the method of discriminant functions. In the present investigation, a maximum gain of 46.19 and 49.36%, respectively for the parental and F_1 generations, could be expected when seed yield and all other characters studied were included in the function. Moreover, with the inclusion of seed yield in the function, the expected gain became maximum in all the combinations. Thus, it may be concluded that the application of the discriminant function can lead to an advancement over straight selection in mustard and that the discriminant function method is superior to straight selection. Similar information was reported by PAUL *et al.* (1976) in *B. juncea*. However, for practical purposes, it is not possible to use all six characters at one time for the selection programme. Therefore, it is always preferable to employ a discriminant function, which would lead to a maximum possible genetic advance by using a minimum number of characters. Expected gains

Table 5

Expected gain in % in seed yield over straight selection from the use of various selection indices

Selection index	Expected gain in %		Selection index	Expected gain in %		Selection index	Expected gain in %	
	Parent	F_1		Parent	F_1		Parent	F_1
1	− 2.62	3.29	1+2+3	25.67	18.74	1+2+3+5	−18.06	− 6.92
2	12.63	15.59	1+2+4	11.33	31.33	1+2+3+6	38.72	34.69
3	11.11	14.67	1+2+5	−19.32	− 9.41	1+2+4+5	−26.00	−21.92
4	− 3.30	− 7.71	1+2+6	28.94	31.33	1+2+4+6	−16.92	13.67
5	− 0.67	−9.22	1+3+4	−11.62	2.44	1+2+5+6	8.63	30.67
6	25.04	34.11	1+3+5	−10.15	−16.31	1+3+4+5	− 1.09	−19.68
1+2	4.11	8.42	1+3+6	31.44	38.36	1+3+4+6	14.67	29.14
1+3	1.32	3.37	1+4+5	0.32	4.30	1+3+5+6	−11.91	−24.63
1+4	0.62	3.97	1+4+6	10.32	11.19	1+4+5+6	− 7.72	−11.94
1+5	− 2.44	−11.42	1+5+6	− 1.30	−17.60	2+3+4+5	−22.67	21.67
1+6	19.44	17.63	2+3+4	31.00	38.62	2+3+4+6	12.67	17.29
2+3	29.11	32.19	2+3+5	−17.60	− 1.02	2+3+5+6	29.90	35.39
2+4	−13.33	−19.00	2+3+6	43.06	48.94	2+4+5+6	−13.33	0.68
2+5	− 6.11	−13.77	2+4+5	−25.11	−31.76	3+4+5+6	−17.85	−14.61
2+6	40.60	41.67	2+4+6	−10.51	31.94	1+2+3+4+5	31.67	34.45
3+4	10.27	17.62	2+5+6	−14.07	26.01	1+2+3+4+6	29.11	29.67
3+5	− 1.09	−10.40	3+4+5	−21.94	−13.76	1+2+3+5+6	33.61	40.31
3+6	37.19	38.99	3+4+6	−10.00	−17.21	1+3+4+5+6	27.65	36.32
4+5	−18.67	−10.49	3+5+6	19.64	27.67	2+3+4+5+6	30.42	34.19
4+6	20.16	23.79	4+5+6	−29.39	−18.81	1+2+3+4+5+6	46.19	49.36
5+6	19.99	31.30	1+2+3+4	30.67	32.67			

1 = Siliqua length
2 = Siliqua number/plant
3 = Primary branch number
4 = Secondary branch number
5 = Thousand seed weight
6 = Yield/plant

of 43.06 to 48.94% can be obtained by using siliqua number/plant, primary branch number and seed yield in the function. Thus, selection on the basis of seed yield/plant, siliqua number/ /plant and primary branch number would appear to be the most effective means of improving seed yield in practical *Brassica juncea* L Czern and Coss breeding.

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DENDROLOGICAL NOVELTIES IN CUBA

The present study contains the descriptions of 17 trees new to science, some of them of potential economic (industrial or ornamental) importance. These new taxa are as follows: *Lauraceae: Ocotea baracoënsis* sp. n., *Persea acunae* sp. n.; *Caesalpiniaceae: Cynometra cubensis* ssp. *ophiticola* ssp. n.; *Fabaceae: Behaimia roigii* sp. n., *Erythrina acunae* sp. n., *Pictetia arborescens* sp. n.; *Rutaceae: Amyris maëstrensis* sp. n., *Amyris verrucosa* sp. n.; *Euphorbiaceae: Ditta maëstrensis* sp. n.; *Celastraceae: Torralbasia cuneifolia* ssp. *verrucosa* ssp. n. and var. *rotundata* var. n.; *Rhamnaceae: Auerodendron acunae* sp. n.; *Theaceae: Laplacea cristalensis* sp. n., *Ternstroemia moaensis* sp. n.; *Combretaceae: Terminalia canescens* sp. n.; *Myrsinaceae: Myrsine cristalensis* sp. n.; *Arecaceae: Coccothrinax borhidiana* sp. n. Taxonomic revisions and analytical keys are contributed for the Cuban species of the genera *Pictetia, Ditta, Torralbasia* and *Myrsine* and for the species group of *Amyris lineata* Wr. ex Griseb. s. l. Two new combinations are also published: *Annona cristalensis* and *Belairia angustifolia*.

Fam.: *Annonaceae*

Annona cristalensis (Alain) Borhidi et Moncada comb. n.

(Basionymon: *Xylopia cristalensis* Alain in Candollea *17*. 1960. p. 108.) *Adde ad descriptionem: Arbor mediocris usque ad 15 m. alta; folia supra lucida, subtus nitida; flores axillares solitarii, usque ad 3 cm longe pedunculati; petala 3, crasse carnosa, usque ad 1—1.5 cm. longa, extus ferrugineo-pilosa; carpella numerosa. Grana pollinica 3-colpata, illis A. cascarilloidis Wr. simillima, non charactere Xylopiarum.*

Specimina examinata: Cuba; Prov. Oriente; Sierra del Cristal, in pluviisilvis serpentinosis montanis ad Cayo Verde, Corea, Mayari Arriba in alt. 650 m.s.m. Leg.: A. Borhidi, M. Vales et Ramona Oviedo 9. apr. 1976. — Charrascal de Saca Lengua, Sierra del Cristal, 2—7. apr. 1956. Leg.: Alain, Acuña et M. López Figueiras 5435 (Holotypus! isotypus!) — Ekman 1559; 14. dec. 1922.

Fam.: *Lauraceae*

Ocotea baracoënsis Borhidi et Imchanitskaya sp. n.

Arbor parva, 5—8. m. alta, cacumen conicum. Folia alterna, obovata vel oblongo-elliptica, apice rotundata vel obtusa, basi angustata, 3—6 cm. longa et 1.5—3 cm. lata, coriacea; supra opaca vel parce nitidula, subtus pallida, cinereo-pruinosa et sparse flavo-sericea, margine tenuiter recurva. Nervi laterales ± rectangulariter abeuntes supra prominuli, subtus prominentes et dense reticulato-venosi. Inflorescentiae (fructiferae tantum visae) axillares 5—7-florae 5—8 cm. longae. Pedunculus 2.5—3.5 cm. longus, glaber, flores subsessiles. Cupula 5—8 mm. longa, semiorbicularis, glabra, margine crenulata vel truncata. Fructus in sicco olivaceo-viridis, oblongo-ellipticus, 12—15 mm. longus; semina ovata apice compressa, 10 mm. longa et 6—7 mm. lata, nigra, papilloso-muricata.

Holotypus: Cuba; Prov. Oriente; Yamanigüey, Baracoa. Leg.: Grupo Samek (27065 SV!); isotypus: 27141 SV!

Obs.: O. moaënsi Bisse affinis, quae a planta nostra foliis supra nitidis, subtus glabris et non cinereo-pruinosis, inflorescentiis 8—12 mm. longe pedunculatis, 3-floris differt.

The wood can be used for furniture and fine constructions.

Persea acunae Borhidi et Imchanitskaya sp. n.

Arbor parva; rami hornotini rubelli, brevissime parceque pilosi. Folia alterna 2—10 mm. longe petiolata, petiolis sparse puberulis suffulta, oblongo-obovata vel oblongo-elliptica, antice breviter acuminata, apice ipso plerumque obtusa, rariter acuta, basi longe cuneata, 4.5—10 cm. longa et 2—3.5 cm. lata, nervo medio supra prominulo, apicem versus applanato, subtus prominenti, lateralibus sub angulo 60—70° abeuntibus, arcuatis, ante marginem conjunctis, utrinque dense reticulatis et prominulis, lamina supra nitidula et glabra, subtus pallida et opaca, brevissime et sparse pilosula vel glabrescens, margine plana, irregulariter et levissime glanduloso-crenulata, coriacea. Inflorescentiae terminales, cymoso-racemosae, usque ad 4—5 cm. longae, foliis breviores; pedunculi 1.5—3 cm. longi, puberuli, pedicelli 2—5 mm. longi, sericeo-hirsuti, rami laterales racemi 3-flori. Sepala exteriora 3, late ovata vel cordata, apice acuta, 1.2—1.5 mm. longa, extus sericeo-puberula, intus glabra. Sepala interiora 3, elliptica vel oblongo-ovata, apice obtusa, 2—2.5 mm. longa, utrinque sericeo-hirsuta. Stamina 9, interiora 3, basi biglandulosa, omnia sericeo-tomentosa. Staminodia 3, 0.5—0.7 mm. longa, apice triangulari-cordata cum filamentis villosis. Ovarium glabrum, oblongo-ovatum, stylus ovario ± duplo longior, stigma late capitatum.

Holotypus: Cuba; Prov. Pinar del Rio; in pulviisilvis montanis montis Pan de Guajaibón supra pag. La Mulata, in alt. approx. 5—600 m.s.m. Leg.: Acuña et Alain (18588 SV!), 16. mai. 1953.

Obs.: P. hypoleucae Mez affinis, quae a specie nostra praeter alias notas sepalis exterioribus ellipticis et minoribus, staminibus exterioribus glabris et appendicibus staminodiorum glabris differt.

The wood is used for rural carpentry.

Fam.: *Caesalpiniaceae*

Cynometra cubensis A. Rich. ssp. *ophiticola* Borhidi ssp. n.

A typo differt: habitu fruticoso, foliolis 0.6—1.5 cm. longis et 0.4—1 cm. latis, laminis utrinque opacis, subtus tenuiter pulverulentis, nervis lateralibus utrinque obsolete impressis vel nullis, legumine subgloboso, 1.5—2 cm. longo.

Holotypus: Cuba; Prov. Pinar del Rio; In lateritis serpentinosis montis La Cajalbana, supra pag. La Mulata. Leg.: Acuña, Roig et Correl (18476 SV!), isotypus: Bp.

The wood is appreciated for fine carpentry.

Fam.: *Fabaceae*

Behaimia roigii Borhidi sp. n.

Arbor parva cortice cinereo; rami hornotini striati et ferrugineo-hirsuti. Folia 7—9-juga, rhachide ferrugineo-tomentosa. Foliola oblongo-ovata vel lineari-ovata, 0.6—2 cm. longa et 0.4—0.7 cm. lata, basi obtusa, apice obtusa et profunde excisa, lamina supra nitidula, subtus opaca, margine revoluta, coriacea. Inflorescentiae axillares, verisimiliter pauciflorae, foliis 2—3-plo breviores, pedunculo fructifero 1—1.5 cm. longo, pedicellis 0.5—0.7 cm. longis. Legumen 2—2.5 cm. longum, 0.8—1.2 cm. latum, utrinque acutum, ferrugineo-puberulum.

Holotypus: Cuba; Prov. Matanzas; Caleta El Rosario; Hacienda El Jiqui, Aguada de Pasajeros. Leg.: Roig et Cremata Nr. 7482 SV! 3. aug. 1920. Isotypus: SV!

Obs.: B. cubensi Griseb. affinis, quae a specie nostra foliis 3—6-jugis, foliolis ovatis vel oblongo—ovatis, 2—5 cm. longis et 1—1.5 cm. latis, inflorescentiis folio ± aequilongis statim discernenda est.

The wood can be used for structural timbers, cross-ties and posts.

Erythrina acunae Borhidi sp. n.

Arbor parva; rami fistulosi, spinis 4—7 mm. longis, lateraliter parce compressis dense aculeati. Petiolus 3—8 cm. longus, 1—1.5 mm. crassus, inermis, petiolulus centralis 1.5—2.5 cm. longus, laterales 3—4 mm. longi, puberuli, stipellae 2, glanduliformes, obovatae, 1—2 mm. longae. Foliola late ovata, basi breviter cordata vel truncata, apice rotundata vel obtusa, 2—5 cm. longa et 2.2—5 cm. lata, basi 5-nervia, superne lateralibus utroque latere 2—4 sub angulo acuto abeuntibus utrinque prominenti-venosa, reticulo venarum supra densiore, subtus magis elevato, lamina utrinque opaca, subtus glaucescens, inermis, chartacea. Inflorescentia glabra, laxe 7—12-flora, rhachide 8—14 cm. longa, pedunculo 2—4 cm. longo; pedicelli subnulli. Calyx bilobus, 8—10 mm. longus, sparse pilosus vel glabrescens, lobi suborbiculares, inferior longior, emarginatus. Vexillum oblongo-ellipticum, rectum vel leviter arcuatum, 3.5—4.2 cm. longum et 14—16 mm. latum. Carinae folia obovato-oblonga, 0.5 mm. longe stipitata, 10—11 mm. longa, superne 3 mm. lata. Alae ellipticae, basi et unilateraliter truncatae, 3 mm. longe stipitatae, apice rotundatae, 10—12 mm. longae et 5 mm. latae. Stamina maxima 3 cm. longa, minima 2.5 cm. longa, antherae 3—4 mm. longae. Ovarium oblongum ± rectum, 5 mm. longe stipitatum, 1—1.2 cm. longum, dense ferrugineo-hirsutum, cca. 6—8-ovulatum. Stylus glaber, attenuatus, 8—10 mm. longus. Fructus non visus.

Holotypus: Cuba; Prov. Oriente; Sierra del Cristal; Residuo de la vegetación del Serrucho, Loma Escalera, Nicaro, Mayari. Leg.: Acuña, Alain et López Figueiras 5405! 2—7. apr. 1956. (flor.!) SV!; isotypus: SV!

Specim. exam.: Ibidem, Acuña et Zayas 19668 SV! 27—28. mai. 1955 (ster.).

Obs.: E. leptopodae Urb. et Ekm. (e Hispaniola) affinis, quae a specie nostra petiolis tenuibus, foliolis nervis lateralibus subhorizontalibus, inflorescentiis densis et multifloris, rhachide 3—5 cm. longa, pedunculo subnullo, pedicellis 3—5 mm. longis, vexillo majore, alis carinisque minoribus, ovario 1.5 cm. longe stipitato clare differt.

This species may be an attractive ornamental tree.

Pictetia DC.

Key to the Cuban species:

1 a Lateral veins of the leaves inconspicuous 2
  b Lateral veins of the leaves prominent above 3
2 a Flowers solitary, pedicels 8—15 mm long, pod entire, or 1—2-segmented (Cuba: LV., Cam., Or., endemic) .... 1. *P. marginata* Sauv.

b Flowers in 2—4-flowered racemes; peduncle 15—20 mm long; pods always contracted or segmented between the seeds (Southern Coast of Oriente, endemic) .... 2. *P. cubensis* Bisse

3 a Leaflets 1—3, pods ovate, 1.5—2.5 cm long, glabrous, not articulate between the seeds (Northern Coast of Oriente, endemic) .... 3. *P. arborescens* Borhidi

b Leaflets 3—7, pods 3—5 cm long, glandular-pubescent, 3—5-articulated (Hispaniola, Cuba: LV., Or.;) .... 4. *P. spinifolia* (Desv.) Urb.

Pictetia arborescens Borhidi sp. n.

Arbor parva, usque ad 5—7 m. alta; rami longe adscendentes, striati, glabri. Spinae stipulares 4—8 mm. longae, plerumque rectae. Folia subsessilia, 1—2 mm. longe petiolata, 1—3-foliolata, foliola oblanceolata vel lanceolata, basi longe angustata, apice integra, obtusiuscula et in mucronem spiniformem 1—2 mm. longum terminata, centralia majora, 2—4 cm. longa et 4—7 mm. lata, nervo medio supra prominulo et anguste sulcato, subtus crasse prominenti, lateralibus utrinque leviter prominulis, vel subtus obsoletis; lamina utrinque glabra, subtus minutissime punctulata, subchartacea. Flores in axillis foliorum solitarii, pedicellis 0.5—2.5 cm. longis, flexuosis, glabris. Bracteae 2 ad apicem pedicelli, oblongo-ellipticae, apice fimbriatae, 0.5—0.8 mm. longae. Calyx 4—5 mm. longus, glaber, tubo 2—2.5 mm. longo, lobi tubo aequilongi, triangulares, apice apiculati et acuti. Vexillum 7—10 mm. longum, alae 10—12 mm. longae, androeceum 8—9 mm. longum. Legumen 3—5 mm. longe stipitatum, ovatum, 1.5—2.5 cm. longum, 6—9 mm. latum, glabrum, prominenter reticulato-nervosum, non articulatum, 1-spermum.

***Holotypus:** 27789 SV! Cuba; Prov. Oriente; in **silvis calcareis** litoralibus ad Playa Pesquero Nuevo pr. Santa Lucia. Leg.: A. Borhidi 15. febr. 1976. Isotypi: 27790 SV! et Bp.*

Obs.: P. spinifoliae Urb. affinis, quae a specie nostra foliis 3—7-foliolatis, floribus majoribus, vexillo 10—13 mm. longo, et fructibus late linearibus, 3—5 cm. longis, 3—5-articulatis sine dubio specifice differt.

Pictetia marginata sensu Alain e Santo Domingo, in Mem. New York Bot. Gard. 21*(2) : 120. 1971. probabiliter* = *P. cubensis* Bisse.

Belairia angustifolia (Griseb.) Borhidi comb. n. Basionym.: Pictetia angustifolia Griseb. in Catalogus Plantarum Cubensium. Lipsiae 1866. p. 73. (Syn.: Belairia ternata Wr. in Griseb. l. c. p. 81.) Citatum huius combinationis novae a clo. Dr. J. Bisse in Ciencias, Botanica, Ser. 10. No. 2. 1975. p. 11. Univ. de la Habana incomplete et errate publicatum.

Fam.: *Rutaceae*

Amyris lineata Wr. ex Griseb. s. l.

As a result of a detailed morphological study this species proved to be a taxonomic complex, which can be separated into three well-defined taxa from a morphological and chorological point of view. The analytical key for their identification is the following:

1 a Leaves lanceolate to linear; the apex long acuminate and acute, sepals triangular-ovate, 0.5—1.5 mm long, petals suborbicular of the same length 2

b Leaves linear; the apex long attenuate, not acuminate, obtuse or rounded; sepals semiorbicular, minute, 0.2—0.3 mm long; petals elliptic, 5—10 times as long as the sepals (Cuba: Or.: Sierra Maestra, endemic) .... 1. *A. maëstrensis* Borhidi et Kereszty

2 a Petiole roughly glandular-muricate, articulate 1—2 mm from the end. Sepals with denticulate margin; ovary covered by lucid resinous points, stigma sessile (Cuba: LV.: Sierra de Escambray, endemic) .... 2. *A. verrucosa* Borhidi et Kereszty

b Petiole glandular, not roughly muricate, articulated at the end. Sepals with entire margin, style thick, 0.3—1 mm long, stigma stipitated (Serpentine latosols of Cuba: PR.: Cajalbana, Or.: North of Oriente, endemic) .... 3. *A. lineata* Wr. ex Griseb.

Amyris maëstrensis Borhidi et Kereszty sp. n.

(Cuaba de la Maestra). *Arbor parva, 8 m. alta (ex León), valde ramosa; rami hornotini tenues, flexuosi, vetustiores levissime longitudinaliter lineato-striati. Folia unifoliolata, 3—10 mm. longe petiolata, petiolis tenuibus flexuosis, glanduloso-punctatis sed non verrucoso-muricatis suffulta, oblongo-linearia, 2.5—6 cm. longa et 0.3—0.6 mm. lata, basi cuneata, antice longe angustata sed non acuminata, apice ipso obtusa vet rotundata, nervis lateralibus parallellis numerosis valde approximatis supra prominulis, subtus prominentibus, lamina supra impresso-punctata, subtus inter nervos sparse glandulosa et minute punctata vel minutissime pulverulenta, utrinque viridis, coriacea. Inflorescentiae laxae, sparsiflorae. Flores minuti, glabri. Lobi calycis 4, semiorbiculares, 0.2—0.3 mm. longi, margine integri, petala oblongo-elliptica, 1.5—2 mm. longa, apice acuta, lobis calycis 5—10-plo longiora; stamina petalis ± aequilonga. Discus 0.5 mm. altus, e lobis calycis manifeste exsertus. Ovarium subglobosum, apice manifeste attenuatum in stylum brevem protractum. Stigma capitatum, breviter stipitatum. Bacca globosa, nigra, 3—4 mm. in diametro.*

Holotypus: Cuba; Prov. Oriente; Sierra Maestra, in silvis montis Loma del Gato in alt. approx. 1000 m.s.m. Leg.: H. Clemente Nr. 5156! dec. 1946. (cum flor. et fruct.) in SV!; isotypus: Bp!

Specim. exam˙: Ibidem, H. Chrysogone Nr. 4254! aug. 1944. (cum flor. et fruct.) — Sierra Maestra: Loma La Barbí, in alt. 800—900 m.s.m. Leg.: León, Clemente et Roca 11. jul.—14. aug. 1921. Nr. 10227! — Sierra Maestra: Mogote Peak. Leg.: Bucher Nr. 135!, febr. 1927.

Amyris verrucosa Borhidi et Kereszty sp. n.

Arbor parva, 6—7 m. alta (ex Jack); rami vetustiores cortice transversaliter dense lenticellati. Folia unifoliolata, 5—10 mm. longe petiolata, petiolis glandulis prominentibus verrucosis, sub apice 1—2 mm. distante articulatis suffulta, lineari-lanceolata, basi obtusiuscula, apice longe acuminata et acuta, 2—5 cm. longa et 0.5—0.8 cm. lata, nervis parallelis numerosis utrinque prominentibus, inter nervos glandulis prominulis suffulta, margine incrassata, integra, coriacea. Inflorescentiae axillares, corymbi pauciflori. Flores brunnei; calycis lobi 4—5, ovati vel triangulari-ovati, 0.5—1 mm. longi, margine crenulato-denticulati, petala valde imbricata, suborbicularia, sepalis ± aequilonga. Stamina 8—10, basi connatis, longe exsertis. Discus glandulosus, 0.5 mm. altus. Ovarium ovatum, punctis resinosis, lucidis obtectum, 1—1.5 mm, longum, apice breviter attenuatum, stylus nullus; stigma sessile.

Holotypus: Cuba; Prov. Las Villas; Sierra de Escambray; Lagunas de Buenos Aires, alt. aprox. 800 m. Leg.: J. G. Jack 9. apr. 1930. (Nr. 7893) SV!; isotypus: Bp!

Fam.: *Euphorbiaceae*

Ditta Griseb.

Adde ad descriptionem: Inflorescentiae masculinae brevissime racemosae, capituliformes, rhachis racemi dense et minute bracteosa, glabra. Flores masculi: sepala 3, imbricata, stamina 3, supra receptaculum adnata, sessilia, filamenta subnulla, inter sese connata. Loculamenta 4, centro connata.

Analytical key to the species of the genus:

1 a Leaves oblong-ovate to oblanceolate, 4—9 cm long, obtuse to emarginate at the apex, glabrous beneath. Bracts obtuse to rounded; male flowers pale green, receptacle thick (Cuba: North Oriente, Hispaniola, Porto Rico) .... 1. *D. myricoides* Griseb.

b Leaves rhombic, 2—4.5 cm long, acute and apiculate at the apex, setiferous-hirsute beneath; bracts apiculate to acute; male flowers yellowish, receptacle thin (Cuba: Or.: Sierra Maestra, endemic) .... 2. *D. maëstrensis* Borhidi

Ditta maëstrensis Borhidi sp. n.

Arbor parva usque ad 6—8 m. alta; rami hornotini flavescenti-virides, flavo- vel ferrugineo-hirsuti. Stipulae ovatae, obovatae vel semiorbiculares, juxta petiolum abeuntes, flabellato-lobatae vel incisae, cca. 1 mm. longae. Folia 2—3 mm. longe petiolata, rhombea vel breviter oblanceolata, utrinque angustata, basi longe cuneata, apice acuminata et acuta, 2—4.5 cm. longa et 0.6—1.8 cm. lata, nervo medio supra prominulo, subtus carinato-prominenti, supra basim valde incrassata et setaceo-hirtula, lateralibus utroque latere 6—9, supra prominulis, subtus prominentibus et anastomosantibus, lamina margine regulariter glanduloso-denticulata, recurva vel anguste revoluta, supra nitida, subtus opaca et setis dense setaceo-puberula, in sicco utrinque flavicans, coriacea. Flores masculi in glomerulis axillaribus racemosis multifloris densisque; rhachis dense bracteata, bracteae minutae, lanceolatae, acutae vel acuminatae. Flores masculi flavi, alabastra 1—1.5 mm. in diam., sepala 3, imbricata, membranacea, utrinque glabra, stamina 3, sessilia, connata, 4-locularia, supra receptaculum tenuiter adnata. Flores feminei axillares, sessiles, plerumque solitarii; sepala 3, vel casu uno absente, inter sese libera, ovata, dorso sparse strigillosa, plerumque resina induta, basi marginis denticulum solitarium glandulosum gerentia, subcoriacea. Ovarium ovatum, glabrum, 2—3-loculare. Capsula depresse-globosa, 6—7 mm. longa et 6—8 mm. in diametro. Semina 2—3, elliptica, 6 mm. longa et 4—5 mm. lata.

Holotypus: Cuba; Prov. Oriente: Cresta de la Sierra Maestra, 1300 m.s.m. Leg.: H. León jul. 1922. Nr. 10883 in SV!; isotypi: 10884 SV! et in NY.

Specim. exam.: Pico Turquino, León 10721! — Loma Regino in 1725 m., Ekman 5297! — Loma Joaquin, cca. 1500 m., Ekman 14465! — Pico Bayamesa, López Figueiras 2124! — Pico Turquino, Acuña 9607! — Entre Loma de Cardero et Pico Cuba in 1500 m., Borhidi, Muñiz et Vazquez 1679! — Pico Suecia in 1700 m., Borhidi, Muñiz et Vazquez 1861!

Fam.: *Celastraceae*

Torralbasia Krug et Urb.

Key to the species of the genus:

1 a Stems brownish to dark grey, smooth and sparsely lenticelled (Cuba: LV.: Sierra de Escambray, Or.: Sierra Maestra; Hispaniola) .... 1. *T. domingensis* Urb.

b Stems greyish, densely verrucated, not lenticelled (Cuba: Or.: North Oriente; Hispaniola, Porto Rico) .... 2. *T. cuneifolia* (Wr.) Krug et Urb.

aa Leaves chartaceous, 1.5—4 cm long, obovate, peduncle 5—15 mm, pedicels 2—4 mm long .... ssp. *cuneifolia*

bb Leaves coriaceous to subcoriaceous; peduncle 15—30 mm, pedicels 4—10 mm long (Or.: Moa-Baracoa, endemic) .... ssp. *verrucosa* Borhidi

aaa Leaves obovate, subcoriaceous, margin hardly recurvate .... var. *verrucosa*

bbb Leaves widely obovate to suborbicular, coriaceous, margin revoluted .... var. *rotundata* Borhidi

Torralbasia cuneifolia (Wr. ex Griseb.) Krug et Urb. ssp. *verrucosa* Borhidi ssp. n.

Frutex vel arbor parva. Rami hornotini leviter angulati, cortice cinerascenti, densissime granulato-verrucosi, elenticellati. Folia 3—7 mm. longe petiolata, petiolis minute verrucosis praedita, obovata vel suborbicularia, 2.5—6 cm. longa et 1—3 cm. lata, subtus punctis resinosis albis densissime obtecta, margine remote denticulata, vel integra, tenuiter recurva, utrinque glabra, coriacea. Cymae axillares, laxiflorae; pedunculus 15—35 mm. longus, rami laterales cymae 5—10 mm. longi, pedicelli 4—10 mm. longi. Sepala semilunaria, usque ad 0.5 mm. longa, petala obovata 1.5—2 mm. longa, filamenta subulata, 1 mm longa. Pericarpium coriaceum, semen ovale, in sicco brunneum, 3 mm. longum.

Holotypus: Cuba; Prov. Oriente; Region de Moa; En el camino de Mina Delta cerca del puente Rio Cayoguán. Leg.: Clemente et Chrysogone 4509!, 4. jul. 1945. SV!

Specim. exam.: Bosque la Breña, Moa; Clemente 4413; — Ibidem, León 22590! — Rio Jaragua, Moa, Clemente, Chrysogone et Nestor 4502! — Arroyo el Soñador, Piedra La Vela, Sierra de Moa; Alain 3246!.

var. *rotundata* Borhidi var. n.

A typo differt: foliis coriaceis late obovatis vel suborbicularibus, apice truncatis vel emarginatis, 2—5 cm. longis et 1.5—3.5 cm. latis, basi breviter cuneatis, margine revolutis.

Holotypus: Cuba; Prov. Oriente; Sierra de Iberia, Taco Bay, Baracoa, leg.: López Figueiras 25. jul. 1960. UO 2210 in SV!

Specim. exam.: Ibidem, López Figueiras 2233! — Moa, Aserradero 26, La Melba, Leg.: Del-Risco 27449 SV!

Fam.: *Rhamnaceae*

Auerodendron acunae Borhidi et Muñiz sp. n.

Frutex vel arbor parva usque ad 5—7 m. alta. Rami teretes, glabri, nigrescenti-striati. Stipulae interpetiolares lanceolatae, obtusae vel acutae, basi brevissime connatae, postremo truncatae, 1 mm. longae, glaberrimae. Folia opposita, petiolis 4—8 mm. longis, angulato-striatis, supra sulcatis, circumcirca glaucopruinosis et glabris praedita, oblongo-ovata, basi obtusa vel truncata, apice acuta vel obtusa et mucronata, 2.5—6 cm. longa et 1—2 cm. lata; nervo medio supra impresso, lateralibus utroque latere 7—9, sub angulo 45—50° abeuntibus, supra impressis, subtus prominentibus et minutissime reticulato-conjunctis, supra nitida, in sicco brunnea, subtus opaca, pallida, utrinque punctis prominentibus, subtus nigris notata, glabra, margine remote undulato-crenulata, chartacea. Inflorescentiae axillares, corymbiformes, glaberrimae, glaucopruinosae. Pedunculi 2—7 mm. longi, bracteae lineari-subulatae 1—1.5 mm. longae; pedicelli 2—4 mm. longi. Alabastra globosa, superne breviter apiculata. Calyx 2.5—3 mm. longus, leviter turbinatus, epunctatus, lobi tubo aequilongi, triangulares, acuti, intus crasse carinati et medio laminula valde prominenti ornati. Petala obovata vel suborbicularia, apice rotundata, integra, late stipitata, 0.8—1 mm. longa. Discus calycis tubum obtegens. Stamina ad marginem disci inserta, filamenta ±1 mm. longa, antherae ovatae, apice acutae. Stylus ±1 mm. crassus, apice truncatus. Ovarium superum, suborbiculare, imperfecte 2-loculare; ovula 2.

Holotypus: Acuña 19702 SV!; Cuba; Prov. Oriente; Sierra del Cristal, Saca La Lengua. Leg.: Acuña et Zayas 26—27. mai. 1955.

Obs.: Habitu A. acuminato (Griseb.) Urb. affinis, quod foliis majoribus, stipulis, petiolis et inflorescentiis puberulis statim discernendum est.

Fam.: *Sabiaceae*

Meliosma herbertii Rolfe

Arbor mediocris usque ad 15—20 m. alta. Rami teretes, lenticellis ellipticis, 1—2 mm. longis obsiti, ferrugineo-hirsuti vel puberuli, mox glabrescentes. Folia alterna, 15—25 mm. longe petiolata, petiolis supra late sulcatis, basi incrassatis plicatisque suffulta, lamina obovato-oblonga vel oblanceolata, basi longe attenuata et cuneata, apice abrupte et 1—1.5 cm. longe acuminata et acuta, 10—13 cm. longa et 4.0—5.5 cm. lata, nervo medio supra impresso et subtus prominenti, utrinque glabro, lateralibus utroque latere 8—12, supra tenuiter prominulis, subtus crassiuscule prominentibus, ante marginem arcuato-conjunctis et utrinque dense reticulatis, margine integra, lamina supra opaca, in sicco brunnea, subtus pallidior, resinoso-punctulata, chartacea vel subcoriacea. Inflorescentiae fructiferae tantum visae, 10—15 cm. longae, paniculatae, ferrugineo-hirsutae. Pedunculus

1.5—2.5 cm. longus et 1—2.5 mm. crassus. Bracteae primariae euphylloideae, 5—15 mm. longe petiolatae, ovato-lanceolatae, integrae, 2.5—5 cm. longae et 1.2—2 cm. latae. Pedicelli fructiferi 2—4 mm. longi. Fructus oblique obovatus, supra basim abrupte contractus, reticulatus, 12—18 mm. longus et 10—13 mm. in diametro, plerumque aborto 1-locularis.

Specim. exam.: 27391 SV!; Cuba; Prov. Oriente. Subida al Yunque de Baracoa. Leg.: E. Del-Risco, 1. febr. 1973. First report from Cuba.

Fam.: *Theaceae*

Laplacea cristalensis Borhidi et Muñiz sp. n.

Arbor parva. Rami teretes cortice brunneo, minute ruguloso, pilis longis adpresse puberulo. Folia 2—5 mm. longe petiolata, petiolis pilosis suffulta, obovata, apice rotundata et breviter emarginata, basi longe cuneata et in petiolum protracta, 3—6 cm. longa et 1.5—2.5 cm. lata, nervo medio supra impresso, subtus prominenti et longe adpresse piloso, lateralibus nullis vel 5—7 paribus utrinque obsoletis; lamina supra glabra, in sicco olivacea vel brunnea, subtus flavescens vel ferrugineo-opaca, resinoso albo-punctata et statu juvenili dense sericea, mox pilis tenuissimis adpressis, e basi tuberculato, brunneo abeuntibus sparse sericeo-pilosa, postremo glabrescens et brunneo-punctata, margine integra, tenuiter revoluta, coriacea. Flores in axillis foliorum solitarii. Pedunculus 3—8 mm. longus, adpresse pilosus, apicem versus dilatatus, 3—4 mm. crassus. Sepala 6—8, obovata, apice rotundata vel truncata, 6—8 mm. longa, dorso dense sericea. Petala 5, ovata, apice rotundata, dorso praesertim basim versus sericeo-puberula, 14—18 mm. longa. Stamina numerosa, filamenta glabra. Ovarium sericeo-villosum; styli basi connati, superne divergentes. Fructus breviter obovatus, 15—20 mm. longus, 5—6-carpelaris, glaber. Semina alata, cum alis usque ad 1—1.2 cm. longa.

Holotypus: Cuba; Prov. Oriente; Sierra del Cristal, "Charrascal de la Falda Sur". Leg: Alain et López Figueiras 4806! 29. dec. 1955. SV!

Specim, exam.: Sierra del Cristal: Los Mulos; leg.: Alain, Acuña et López Figueiras 5362! — Inter Los Mulos et Corea, alt. aprox. 630 m.; leg.: López Figueiras UO 212! — Rio Lebisa; leg.: López Figueiras, UO 203!

Obs.: L. benitoënsi (Britt. et Wils.) O. C. Schmidt affinis, quae a planta nostra foliis supra nitidis, subtus glabrescentibus et pilis basi non tuberculatis suffultis, epunctatis, petiolis longioribus, pedicellis brevioribus et tenuibus, sepalis 5, petalis glabris, multo minoribus differt.

Ternstroemia moaënsis Borhidi et Muñiz sp. n.

Frutex vel arbor parva usque ad 6—7 m. alta. Rami oppositi, hornotini ruguloso-striati, flavicantes, vetustiores cinerascentes. Folia 2—10 mm. longe petiolata, obovata vel oblongo-obovata, basim versus angustata et in petiolum protracta, apice rotundata et emarginata vel anguste excisa, 6—10 cm. longa et 3—5 cm. lata, nervo medio supra inferne impresso vel plano, superne crassiuscule prominulo, subtus per totam longitudinem prominenti, lateralibus utrinque conspicuis et tenuiter prominulis, marginem versus obsoletis, lamina margine incrassata, integra et valde revoluta, crasse coriacea. Pedunculus 2—4 cm. longus, prophylla late ovata vel orbiculari-ovata, 5—6 mm. longa et 4—5 mm. lata, apice apiculata et acuta, margine glandulosa. Sepala 5, oblongo-ovata vel elliptica, 10—12 mm. longa, exteriora margine glandulosa, interiora margine membranacea, glabra. Ovarium biloculare; fructus ovatus, apice rotundatus vel truncatus, 15—18 mm. longus et 10—14 mm. latus. Semina 2—6.

Holotypus: Cuba; Prov. Oriente; in charrascosis montis Cerro de Miraflores inter Moa et Cananova. Leg.: A. Borhidi, R. Capote et Ramone Oviedo 12. sept. 1974. 27821 SV!; isotypus: Bp.!

The wood is used in rural carpentry.

Fam.: *Combretaceae*

Terminalia canescens Borhidi et Muñiz sp. n

Arbor 15 m. alta; truncus rectus, cacumen late rotundatus. Folia obovata vel elliptica, 7—10 cm. longa et 2.5—4.5 cm. lata, 7—12 mm. longe petiolata, apice obtusa et brevissime apiculata, basi breviter cuneata vel obtusiuscula, margine tenuiter revoluta; nervo medio supra inferne prominenti, apicem versus applanato, lateralibus 8—9 supra planis vel tenuiter prominulis, subtus bene prominentibus, ante marginem arcuato-conjunctis et anastomosantibus; lamina utrinque, praesertim ad nervos pilis longis tenuibusque albis arachnoideo-tomentosa, chartacea. Inflorescentiae axillares 10—12 cm. longae, folia paullo superantes, 4—6 cm. longe pedunculatae, breviter ferrugineo-floccosae et pilis longis albis canescenter tomentosae, multiflorae. Hypanthium 2—2.5 mm. longum et 1.5—2 mm. latum, tubus calycis 3 mm. longus; lobi 5, late triangulares, 1—1.5 mm. longi, apice incrassati, extus cum tubo ferrugineo et canescenti tomentosi, intus glabri. Stamina 10, in seriebus duabus, exteriora ad tubum calycis in fauce adnata, filamenta 1—2 mm. longa, glabra. Stylus cylindraceus, apice attenuatus, glaber. Discus ferrugineo-villosus.

Holotypus: Borhidi 4374; Prov. Oriente; in silvis deciduis vallis Rio Tacre pr. pag. Cajobabo, Sur de Baracoa. Leg.: A. Borhidi, O. Muñiz et S. Vazquez, 17. mart. 1970. SV!; isotypus: Bp !

The wood can be used for furniture, and fine constructions, structures, heavy plankings and cross-ties.

Fam.: *Myrsinaceae*

Myrsine L.

Analytical key to the Cuban species:

1 a Young stems pubescent to tomentose with ferrugineous hairs (Or., LV., Neotropics) .... 1. *M. coriacea* (Sw.) R. Br.
  b Young stems glabrous 2
2 a Leaves coriaceous, 8—25 mm long, 6—11 mm wide, fruit 3—3.5 mm in diameter (Or.: Sierra Maestra, endemic) .... 2. *M. microphylla* (Britt. et Wils.) Alain
  b Leaves chartaceous to subcoriaceous, leaves and fruit larger 3
3 a Leaves obovate, 1.8—4 cm wide, pale and dull beneath; flowers 4—5-merous, petals obtuse, pulverulent at the margin (Cuba: PR., IP., Hab., Mat., LV., Cam.; endemic) .... 3. *M. cubana* A. DC.
  b Leaves oblong-elliptic or oblanceolate, 0.8—2.2 cm wide, shiny beneath, flowers 4-merous, petals lanceolate, acute, membranous, glabrous at the margin (Cuba: Or.: Sierra del Cristal, endemic) .... 4. *M. cristalensis* Borhidi

Myrsine cristalensis Borhidi sp. n.

Arbor parva vel mediocris usque ad 15 m. alta, corona oblongo-pyramidata. Rami hornotini flexuosi, brunnei, glabri, vetustiores cinerei. Folia 4—10 mm. longe petiolata, oblongo-elliptica, oblongo-obovata vel oblanceolata, apice obtusa, rotundata vel truncata et emarginata, basi longe cuneata et in petiolum protracta, 2—5.5 cm. longa et 0.8—2.2 cm. lata, nervo medio supra prominulo, subtus prominenti, lateralibus utrinque nullis vel obsoletis; lamina supra nitida, in sicco brunnea, plicatula, punctis impressis sparsis, subtus leviter pallidior, nitidula, glandulis prominentibus obsita, utrinque glabra, leviter obliqua, chartacea vel subcoriacea. Flores in fasciculis brevissime pedunculatis, 0.5—1 mm. longe pedicellati, 4-meri. Sepala 0.7—1 mm. longa, lanceolata, longe acuminata et acuta, margine glabra. Petala ovata vel lanceolata, basi usque ad 1/4 partem connata, apice acuta et plerumque acuminata, 2—2.5 mm. longa, margine membranacea, glabra. Antherae 1.5—2 mm. longae, apiculatae, petalis manifeste breviores. Ovarium ovatum. Fructus non visus.

Holotypus: Cuba; Prov. Oriente; Sierra del Cristal, Bosque húmedo de Cayo Verde. Leg.: H. Alain et López Figueiras 26. dec. 1955. 4529! SV.

Specim. exam.: Bosque húmedo de Cayo Verde in alt. aprox. 650 m.s.m. Leg.: A. Borhidi et M. Vales 9. apr. 1976. — Charrascos cerca del Cumbre del Cristal, 2—7. apr. 1956. Leg.: Alain, Acuña et López Figueiras 5636!

Obs.: M. punctatae (Lam.) Stearn affinis, quae a specie nostra foliis minoribus, obovatis, 2—3 cm. latis, supra manifeste punctatis, floribus 4—5-meris, ovario rotundato differt.

Myrsine cubana A. DC. is a valid endemic species of the flora of Cuba. *(Rapanea guianensis auct. cub. non Aubl.)*

Fam.: *Arecaceae*

Coccothrinax borhidiana Muñiz sp. n.

Palma 4—7 m. alta; caudex usque ad 8—20 cm in diametro, foliis siccis, permanentibus dense obtectus. Vagina frondis usque ad 70 cm longa, pars libera ovata, usque ad 20 cm longa, fibris flexuosis capilliformibus, 0.5—1 mm. crassis in unum stratum dispositis laxe intertexta. Petiolus biconvexus usque ad 10 cm longus, ad apicem 2 cm latus. Ligula revoluta, fibroso-intertexta. Lamina suborbicularis, rigida, supra viridis, subtus pallida, punctulis concoloribus vix conspicuis praedita; segmenta 32—36, centralia 60—65 cm longa, basi 22—25 cm longe connata, dimidio 4.5 cm. lata, apice in acumen 9—10 cm longum abrupte contracta. Spadix usque ad 110 cm. longus, ascendens, rectus, spathae coriaceae, glabrae, apice acutae, saepe fibrosae. Inflorescentiae partiales 4—5, pars ramosa 30—35 cm longa, ramuli floriferi inferiores 12—18 cm longi, pedicelli floriferi 1.5—3 mm longi, 0.5—0.8 mm crassi. Perianthii lobi 6, stamina plerumque 8—9, filamenta lineari-subulata, perianthii dentes paullo vel 1 et 1/2-plo superantia. Fructus maturi nigri, glabri, subglobosi, 7—9 mm. in diametro. Semen depresso-globosum, 5—6 mm in diametro, profunde sulcatum.

Holotypus: Cuba; Prov. Matanzas; Litus calcareum maritimum altum in Punta Seboruco inter Jibacoa et Matanzas. Leg.: O. Muñiz 14. mai. 1970. 27118 SV!; isotypus: Bp!

Specim. exam.: Ibidem, Leg.: A. Borhidi, E. Del-Risco, R. Capote, 29. mai. 1974.

Obs.: C. crinitae Becc. habitu affinis, quae a specie nostra forma robustiore, vaginae fibris tenuissimis multistratis et dense intertextis, foliis majoribus, longe petiolatis, segmentis 50—52, usque ad 1 m longis; inflorescentiis partialibus 6—11, multo longioribus, pedicellis crassis, staminibus 12 et fructibus majoribus, 15—20 mm in diametro facillime distinguitur.

The leaves are used for roof covering in farmhouses.

*

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A. Borhidi, N. Imchanitskaya, O. Muñiz

DIALLEL CROSS ANALYSIS OF QUANTITATIVE CHARACTERS IN CIGAR WRAPPER TOBACCO

The practical utility of studying quantitative characters in any crop in order to determine their influence on yield potential is well-known. In cigar tobaccos not much work seems to have been done in this direction. Keeping this in view, the present study was carried out in order to give an idea of the additive and dominance effects of genes in a set of diallel crosses in this crop.

An 8×8 set of diallel crosses was made by crossing eight cigar wrapper (*N. tabacum* L.) varieties, namely, Rangpur Sumatra, Farmson's marilla, Monteculm brun, S.A. 40—31, Magnolia, Rg, Sumatra and Dixie shade. The parents and all possible F_1's were raised in a randomized complete block design with two replicates. Five randomly selected competitive plants were used for observation. The data were recorded for total number of curable leaves per plant, total laminar length, breadth and laminar area per plant, cured leaf and seed yield per plant and days to flowering.

The data were analyzed using HAYMAN's (1954) method for testing the additive and dominance effects in the diallel crosses. The additive variance between the parents and the maternal effects is represented by the equation:

$$Y_{rs} = m + j_r + j_s + j_{rs} + k_r - k_s + k_{rs}$$

where m = grand mean, j_r = mean deviation from the grand mean due to rth parent, j_{rs} = remaining discrepancy in the rsth reciprocal sums, k_r = difference between the effects of the rth parental line used as male parent and as female parent, k_{rs} = remaining discrepancy in the rsth reciprocal difference. The four sums of squares are denoted as (a), (b), (c) and (d). For the more precise interpretation of dominance differences between parental mean, progeny mean and the deviations due to specific parents, it can be given as:

$$Y_{rs} = m + j_r + j_s + l + l_r + l_s + l_{rs} + k_r - k_s + k_{rs} \qquad (r \neq s)$$

$$Y_r = m + 2_{jr} - (n-1)l - (n-2)l_r$$

where l = mean dominance variation

l_r = further dominance deviation due to the rth parent

l_{rs} = remaining discrepancy in the rsth reciprocal sum.

Each error entered in Table 1 is the interaction with the environment of the corresponding mean effect and since the additive and dominance variation may not be expected to be influenced to the same extent by the environment, each mean should be tested against its own interaction. However, the error variances have been pooled to give a common error variance (Bt) and the mean in each case has been calculated by using this.

Estimates of components of variation show that the parents used here gave significant variations for all the characters studied (Table 1).

The cultivars showed significant reciprocal differences for all the traits. The maternal effects were observed only for the laminar area, cured leaf and seed yield and days to flowering. The existence of maternal effects indicates that caution should be exercised in choosing the maternal parent. Parents giving better results as a mother should only be used as a mother in these crosses. In cigar filler tobacco (DUBEY 1975, LUKOSEVICIUS 1970) maternal effects have also been observed.

Regarding the dominance genetic variation, its various components b_1, b_2, and b_3 provided an estimate of mean dominance variation, further dominance variation due to a particular parent and the remaining discrepancy in the rsth reciprocal sum, respectively. The significance of b_1 clearly indicated the presence of dominance for all the characters except days to flowering. Component b_2 showed an irregular distribution of genes controlling these seven quantitative characters in the cultivars used. Quite significant estimates of b_3 were also obtained for all the characters. Also in other cultivars of tobacco (POVILAITIS 1964, GOPINATH *et al.* 1967) dominance effects have been recorded. Marked variability for seed yield was also observed. Genes controlling seed yield also exhibited dominance and an asymmetrical distribution.

Table 1

Analysis of variance for different characters in tobacco

Components	Constants	df	Number of curable leaves	Total laminar length	Total laminar breadth	Total laminar area	Total cured leaf yield	Total seed yield	Days to flowering
			Mean sum of squares for different characters						
a	j_r	7	92.60**	212 613**	76 076**	755.3**	1848**	143.8**	465.0**
b_1	l	1	18.00**	111 250**	32 112**	307.3**	782**	329.9**	5.0
b_2	l_r	7	8.60**	38 885**	9 242**	105.9**	191*	223.4**	27.1**
b_3	l_{rs}	20	5.30**	20 957**	6 913**	81.8**	354**	240.0**	18.8**
b	j_{rs}	28	6.60**	28 664**	8 396**	96.0**	328**	239.0**	20.0**
c	k_r	7	2.20	9 262	3 314	25.5**	274**	204.0**	3.6
d	k_{rs}	21	2.00	5 899	1 432	14.0	396**	51.0**	37.0**
		63	14.10	393 559	13 029	134.0	514	162.0	77.0
B		1	5.00	27 848	8 450*	61.0*	599*	24.0	23.0**
Ba		7	1.30	3 574	753	6.6	30	17.5	1.1
Bc		7	1.50	2 773	564	4.2	64	19.0	3.0
Bt		63	1.28	5 049	1 415	8.3	93	15.7	1.9

* $P < 0.05-0.01$
** $P < 0.001$

In some of the cases differences due to blocks were also present to a certain extent, which may be attributed to minor variations in the edaphic conditions. Interactions such as Ba and Bc were not significant for any of the traits.

The genetic divergence and asymmetrical gene distribution present in the varieties used for the characters measured provided an opportunity for improving the yield potential of these varieties.

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CALIBRATION OF SOIL TESTS WITH NITROGEN NEEDS OF A DWARF WHEAT (T. *AESTIVUM)* IN MOLLISOLS OF UTTAR PRADESH (INDIA)

Crop yields are generally correlated with soil tests in Mitscherlich—Baule type response curves and are supposed to be independent of other factors influencing the yield. But generally the response curves are not of this type and their mathematical and statistical foundations have been questioned (Colwell—Esdaile 1968). When correlating the soil tests for a particular nutrient with yields, factors other than soil test values should also be given due consideration. Correlation studies are generally carried out either in a pot culture or in the field. In the former case the profile distribution of mobile available nutrients and the physical properties of the soils are disturbed and are different from those *in situ;* hence this method is not appropriate for such studies, and field experiments are therefore preferred. In the latter case there have recently been two approaches for conducting the experiments:

1. Experiments are conducted at different locations and the results are compiled, as is being done in Australia (Colwell 1967, Colwell—Esdaile 1968).

2. A wide variation is created in soil fertility in one and the same location and complex experiments are conducted at a few such locations, as is being done in India (Ramamoorthy—Velayutham 1971). Location differences due to factors other than soil fertility do not vitiate the results and the statistical confidence is higher.

In India, due to the wide variation in soils and climate, the first approach has not given satisfactory results and the second one is preferred. The calibration curves are developed separately for each soil-climate-crop complex. A curvilinear regression between the soil test values of nitrogen, phosphorus, potassium, the fertilizer doses and their interactions on the one hand and yield/yield response of the crops on the other has generally been obtained (Ramamoorthy 1973). Adjustment equations are derived for fertilizer doses under different soil test values. In the present study, therefore, this approach was tried in a mollisol soil with wheat as the test crop.

The experiment was conducted at the experimental station of G.B. Pant University of Agriculture and Technology, Pantnagar (Nainital). The soils of this area, popularly known as Tarai soils of U. P., have developed on calcareous, medium to moderately coarse textured material with a high micaceous component, under the influence of mixed tall grass and forest vegetation in a monsoon type of climate. The soils have been classified as mollisols (Deshpande *et al.* 1971). The experiment was located on an aquic hapludoll (Deshpande *et al.* 1971) which had a fine silty texture. This type of soil is very widespread in the wheat growing belt of the sub-Himalayan plains in North India.

The experiment was conducted in two phases. In the first phase, i.e. in the preparatory trial, a 0.8 ha plot was divided into four strips of equal size. To obtain a sufficient range of soil fertility with respect to nitrogen, phosphorus and potassium, graded doses of N, P and K were applied in three strips using urea, single superphosphate and muriate of potash, respectively. One strip was kept as the control.

A uniform fodder maize crop was grown to stabilize the fertility gradient by allowing the fertilizer nutrients to react for one crop season in a soil-plant system. The fodder was harvested after 75 days. The soil fertility variations with respect to N, P and K in the aquic hapludolls of this area are generally due to differences in the previous fertilizer doses and soil management. The prepared plot was therefore used as a simulation of the fertility variation in the area.

In the second phase, each of these strips was subdivided into plots 10×4 m in size. Composite soil samples were collected at a depth of 0—15 cm from each of theses plots, then dried, passed through a 2 mm sieve, and analyzed for available nitrogen by the Alk. $KMnO_4$-

method (SUBBIAH—ASIJA 1956), for organic carbon (WALKLAY—BLACK 1934), for available phosphorus by Olsen's method (OLSEN *et al.* 1954), and for available potassium by the ammonium acetate method (HENWAY—HEIDEL 1952). The response of various combinations of 5 levels of nitrogen (0, 50, 100, 150 and 200 kg N/ha), 4 levels of phosphorus (0, 5, 1000 and 150 kg P_2O_5/ha) and 3 levels of potassium (0, 50 and 100 kg K_2O/ha) to a two-gene-dwarf wheat (variety Kalyan—Sona) was studied in each of these strips separately.

The treatments were randomized within each of the four strips separately. Each treated plot was sandwiched between control plots to take care of local heterogeneity. Half of the nitrogen as urea was basal dressed and the rest top dressed 30 days after sowing at the time of the second irrigation. The whole quantity of phosphorus and potassium was broadcast in the form of single superphosphate and muriate of potash respectively before sowing. Standard agronomic practices were adopted and during harvesting the total yield, grain yield and straw yield of the individual plots were recorded. The yield response for each treated plot was calculated by subtracting the average yield of the two adjacent control plots from the yield of the treated plot. Multiple regression equations were worked out for various functions with the help of a computer.

Multiple regression equations for the treated plots correlating the soil test values (kg/ha) for nitrogen (N), phosphorus (P) and potassium (K) (Sn, Sp and Sk respectively) and doses (kg/ha) of nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) (Fn, Fp and Fk respectively) on one hand with yield(Y)/yield response(YR) in kg/ha on the other for two selected functions were calculated. Their R^2- values are given in Table 1.

From Table 1 it is evident that the highest predictability (48%) is obtained with function 2, when the regression of the yield on soil test values and fertilizer doses and the interaction between soil and fertilizer nutrients has been tried. In this function the value of R^2 is the same in both cases, whether organic carbon or alk. $KMnO_5$—N is used as the index of available soil nitrogen. However, since a routine analysis of organic carbon is easier in the soil testing laboratory, this procedure will be more suitable than the alk. $KMnO_5$—N method. The equation using organic carbon as the index of soil nitrogen was:

$$\begin{aligned} Y = {} & 4572 - 4480\ Sn + 2557\ Sn^2 - 28.88\ Sp \\ & + 0.4736\ Sp^2 + 13.39\ Sk^* - 0.0227\ Sk^2 + 30.53\ Fn^{**} \\ & - 0.0943\ Fn^{2**} + 0.58\ Fp + 0.0109\ Fp^2 + 9.81\ Fk \\ & - 0.0026\ Fk^2 - 5.99\ Sn\ Fn - 0.0328\ Sp\ Fp \\ & - 0.0432\ Sk\ Fk\ (R^2 = 0.48^{**}) \end{aligned} \tag{1}$$

Table 1

R^2 of different response functions

Function	R^2	
	Yield (Y)	Yield Response (YR)
1. Regression of yield/yield response on soil test values and fertilizer doses:		
a) Using organic carbon as index of soil nitrogen	0.46**	0.35**
b) Using Alk. $KMnO_4$—N as index of soil nitrogen	0.46**	0.32**
2. Regression of yield/yield response on soil test values and fertilizer doses and interaction between soil and fertilizer nutrients:		
a) Using organic carbon as index of soil nitrogen	0.48**	0.37**
b) Using Alk. $KMnO_4$—N as index of soil nitrogen	0.48**	0.37**

The coefficients of fertilizer phosphorus (Fp) and fertilizer potassium (Fk) are not significant, whereas those of fertilizer nitrogen (Fn) are highly significant (**). This is due to the high soil fertility with respect to P and K in these soils. On isolating the partial derivative of Fn alone, therefore, and examining the signs of the linear, quadratic and interaction terms for fertilizer nitrogen (Fn) in Eq. (1), a response function of the following type is obtained, which is best suited for formulating the adjustment equation for the different fertilizer doses at various soil test values:

$$Y = a + b\,Fn - c\,Fn^2 - d\,SnFn \qquad (2)$$

where a is the constant independent of Fn and Sn, b, c and d are regression coefficients, and Sn and Fn stand for the soil and fertilizer portions of nitrogen.

On differentiating Eq. (2):

$$\frac{dy}{dFn} = b - 2c\,Fn - d\,Sn \qquad (3)$$

Since $\frac{dy}{dFn} = 0$ under conditions of maximum yield,

$$Fn = \frac{b - dSn}{2c} \qquad (4)$$

Putting the values of b, c and d (the regression coefficients of Fn, Fn^2 and SnFn respectively) into Eq. (4):

$$Fn\,(\max.) = 162 - 31.7\,Sn \qquad (5)$$

where Fn = fertilizer (N) dose (kg/ha) for maximum yield of wheat,

Sn = soil test value, i.e. percentage organic carbon.

In order to arrive at the economically optimum dose, however, the consequences of the law of diminishing returns have to be kept in mind. Under such conditions:

$$p\Delta Y = q\Delta Fn \qquad (6)$$

where p = price of wheat grain

q = price of fertilizer nitrogen.

From Eq. (6) it follows that

$$\frac{dy}{dFn} = \frac{q}{p} \qquad (7)$$

From Eqs (3) and (7):

$$Fn\ (eco) = \frac{\left(b - \frac{q}{p}\right) - dSn}{2c} \qquad (8)$$

Putting in the values of b, c and d:

$$Fn\,(eco) = 162 - 5.30\,PR - 31.7\,Sn \qquad (9)$$

where PR = price ratio, i.e. $\frac{q}{p}$

Here Fn (eco) is the most profitable dose of fertilizer nitrogen (kg/ha) with a soil test value (percentage organic carbon) of Sn and a price ratio of PR. This dose is to be recommended for maximum profit per hectare as compared to fertilizer use.

However, when a limited amount of capital could be alternatively used for other farming or non-farming purposes, the "desired return per last rupee of investment" in fertilizer becomes an important criterion for making fertilizer recommendations. Under such conditions:

$$p\Delta Y = DR \times q\Delta Fn \tag{10}$$

where DR = desired marginal returns on investment in fertilizers.

From Eqs (3) and (10),

$$Fn\ (eco)_{DR} = \frac{b - (PR \times DR) - dSn}{2c} \tag{11}$$

where PR = price ratio, i.e. $\frac{q}{p}$, as defined earlier.

Putting in the values of b, c and d:

$$Fn\ (eco)_{DR} = 162 - 5.30\ PR \times DR - 31.7\ Sn \tag{12}$$

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STUDIES ON BIOCLIMATOLOGY OF RICE

Although rice is considered to be a tropical or sub-tropical crop, the best rice yields are obtained in temperate regions (De Datta 1973). In tropical areas only a few major studies on climatology have been carried out. However, from the available reports it can be assumed that the productivity of a crop that is well-fertilized and supplied with sufficient water would be mainly determined by the climate. Under these circumstances it would be necessary to identify the climatic parameters most conducive to the proper growth and development of rice. Since there is not much information available on the response of water management in different periods of the year this aspect was also included in the study.

The experiment was conducted during 1972 and 1973 at the Central Rice Research Institute, Cuttack. There were 18 monthly sowings in the main plot from January to August and in December of each year. The 3 sowing months of September, October, and November were left out on account of the cold damage to the crop in these months. The water management treatments consisted of intermittent irrigation (0 to 5 cm) and continuous flooding (5 to 10 cm) set up in the subplot. The four high yielding dwarf varieties Bala, Ratna, Vijaya and Jayanthi were accommodated in subplots. The experimental design was a split plot with two replications. The crop was planted in a spacing of 15×10 cm in plots of gross size 3.70×2.25m and met size 3.10×1.95 m.

Meteorological data such as maximum and minimum air temperature, sunshine hours and relative humidity were collected from the meteorological observatory which is situated very near to the experimental field. Solar radiation was measured by a solarimeter. The soil water interface temperature of the paddy field was measured by inserting the bulb of the thermometer in the soft wet mud and reading the values at 8 a.m. and 2 p.m. Even though 4 varieties were grown, for the purpose of working out correlation coefficients only one variety (Vijaya) was used, since all the varieties showed a uniform trend in the different sowings. The entire growth period was split up into vegetative, reproductive and ripening phases and the growth attributes were correlated with the meteorological conditions experienced by the crop during that particular period.

Plant height. The data presented in Table 1 revealed that an increase in plant height was observed as the sowing month advanced from January to June and decreased thereafter, reaching a minimum in the December sowing. The variety Vijaya had the maximum height recorded, followed by Ratna, Jayanthi and Bala (Table 2). More height has been recorded with continuous flooding than with intermittent irrigation because of the influence of standing water in increasing the height (Irri 1968) due to the elongation of the internodes.

The data on height at different stages and minimum air temperature at the vegetative phase showed that the height at preflowering stages was greater when the night air temperature during the vegetative phase was higher. The correlation coefficients also showed that the height of the plant was positively correlated with the minimum air temperature ($r = 0.6564^{**}$) at the vegetative phase. Minimum soil water interface temperature also increased the height significantly ($r = 0.5768^{*}$). Such increases in height were also reported by Sato (1972) and Osada *et al.* (1973) which might be attributed to the increased nutrient uptake due to high temperature (Chiu *et al.* 1960).

Solar radiation negatively influenced the height, especially at the reproductive phase (-0.5665^{*}) and the ripening phase (-0.5488^{*}). The limited supply of light to the base of the plant at later stages consequent on mutual shading might have led to an elongation of the lower

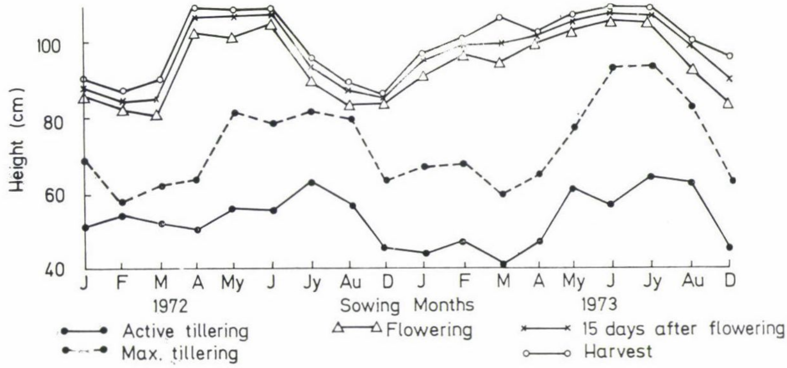

Fig. 1. Plant height at different stages (Vijaya)

Table 1

Growth attributes as influenced by sowing

Sowing months	Height (cm)	LAI at lowering	Dry matter production at flowering (kg/ha)
1972			
January	87.0	5.01	7104
February	84.7	4.46	6521
March	86.1	4.81	7068
April	95.1	5.14	6687
May	99.0	6.29	5603
June	101.6	6.91	6119
July	92.3	5.59	6695
August	88.3	6.63	7502
December	81.2	5.23	6733
1975			
January	90.1	4.95	7530
February	91.9	5.52	7508
March	90.3	4.96	7389
April	97.5	5.54	7139
May	100.9	7.35	6709
June	101.2	6.53	6347
July	98.7	5.82	7302
August	90.4	5.05	7891
December	87.9	5.47	6984
CD for comparison of sowings	1.97**	0.35**	53**

** Significant at 1% level

Table 2

Growth attributes as influenced by varieties and water management

Attributes	Varieties					Water management		
	Bala	Ratna	Vijaya	Jayanthi	C.D.	Intermittent irrigation	Continuous flooding	C.D.
Height	88.4	92.0	98.5	90.9	1.02**	90.2	94.7	0.60**
LAI	4.45	5.48	6.51	6.07	0.16**	5.82	5.44	0.12**
Dry matter production	5866	7333	7097	7444	21**	7030	6840	16**

** Significant at 1% level

Table 3

Partial correlation coefficients between height at harvest (factor 1) with sunshine hours (facıor 2) and the mean relative humidity (factor 3) during the vegetative, reproductive and ripening phases of Vijaya

Factors	r-value
12	—0.7884**
13	0.6358**
23	—0.8769**
12.3	0.6223**
13.2	—0.1878

** Significant at 1% level

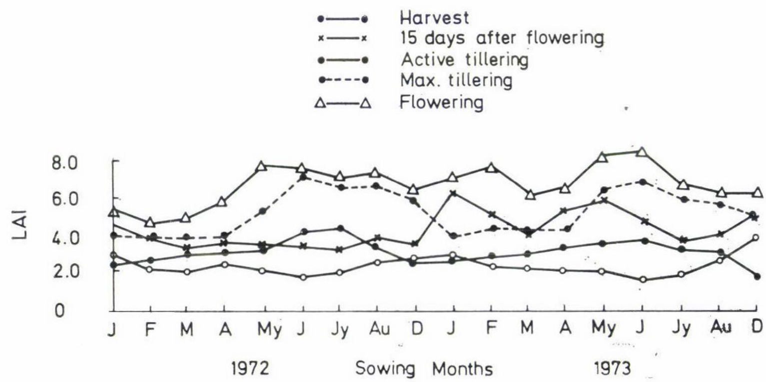

Fig. 2. LAI at different stages (Vijaya)

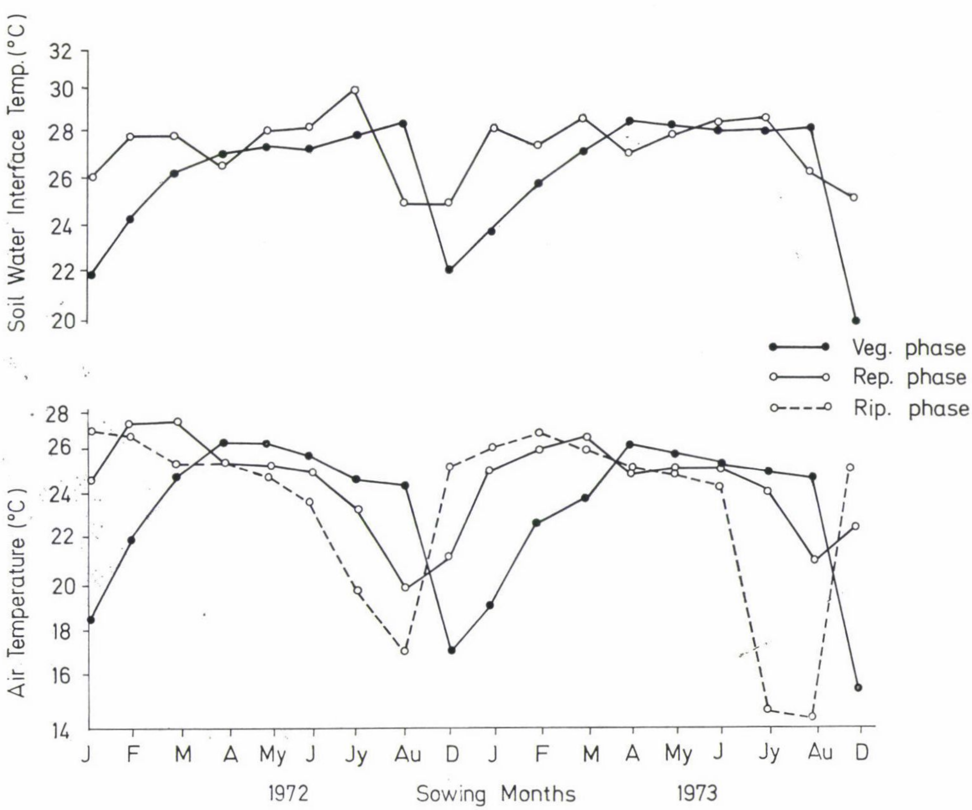

Fig. 3. **Minimum air and soil water interface temperature at different phases (Vijaya)**

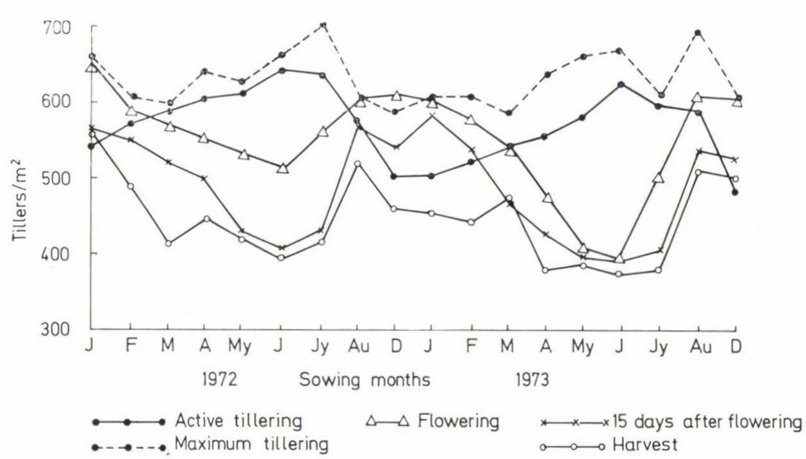

Fig. 4. **Tillers at different stages (Vijaya)**

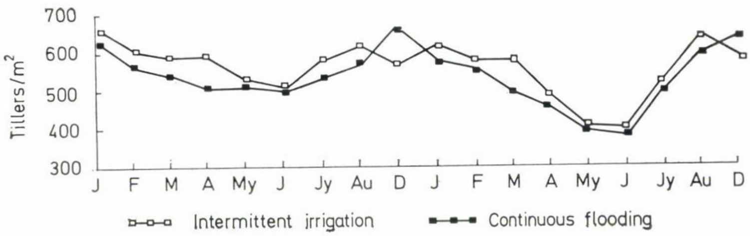

Fig. 5. Tillers at flowering as influenced by water management practices

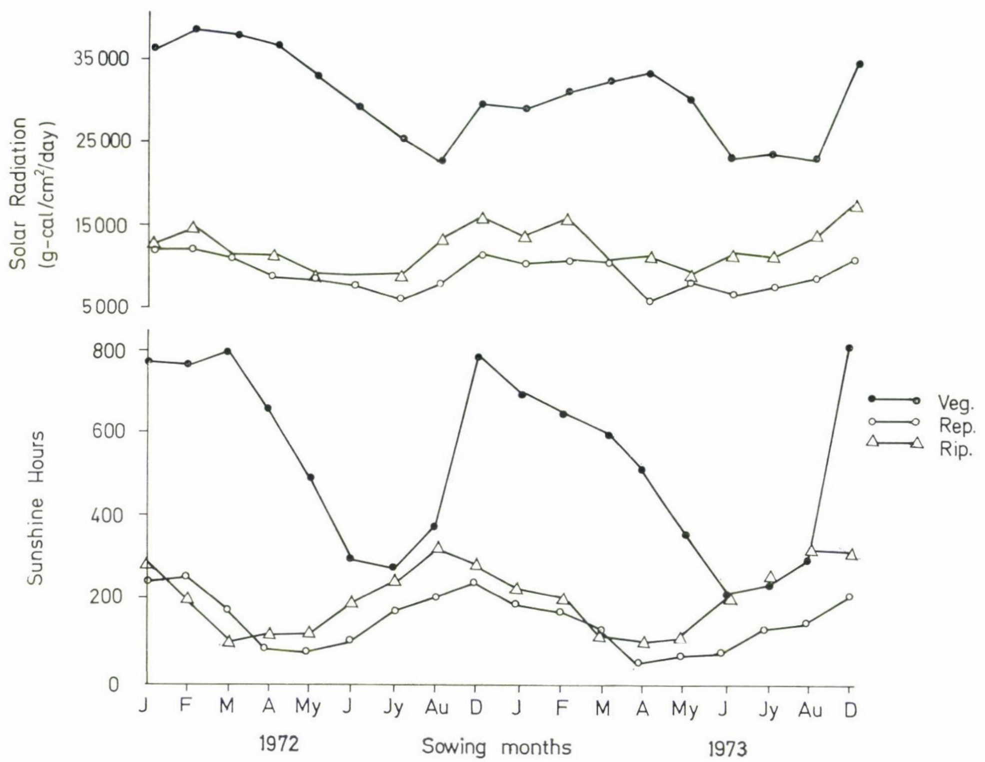

Fig. 6. Total sunshine hours and solar radiation during different growth phases (Vijaya)

internodes. This was probably an adaptation of the plant under low light conditions during the monsoon season. Ghosh (1961) and Tanaka *et al.* (1966) corroborated these findings. Even though plant height at harvest was positively correlated with relative humidity (0.6358**), the partial correlation coefficients calculated (Table 3) showed that when the effect of sunshine hours was eliminated the correlation between height and relative humidity not only became non-significant but also changed its sign from positive to negative. Thus relative humidity per se had no influence on the height of plants. This is further proved by the close negative correlation of sunshine hours with relative humidity.

Leaf area index (LAI) at flowering. LAI at flowering was maximum for the May and June sowings and lowest in the December and January sowings (Table 1). Figure 2 shows that

LAI during the first 3 stages was maximum in the wet season sowings of May and June and minimum in the December and January sowings, whereas LAI at the reproductive and ripening phases showed a reverse phenomenon, wherein the lowest LAI was recorded in the May/June sowings in both years. This decrease was probably due to the death of many leaves consequent on mutual shading. The intermittent irrigation gave a significantly higher LAI than continuous flooding (Table 2). This might be due to the higher number of tillers produced in intermittent irrigation plots (Fig. 5) in most of the sowings. Since LAI is the integral of tiller number, leaf per hill and the size of leaves, it is mostly determined by tiller number (TANAKA *et al.* 1964), since the number of leaves on a tiller is constant. The varietal differences (Table 2) show that Vijaya gave the highest LAI, followed by Jayanthi, Ratna and Bala. The correlation coefficients calculated between the LAI of Vijaya at flowering and various meteorological elements showed that this character was negatively correlated with solar radiation during the vegetative phase (—0.5877*) and the reproductive phase (—0.5458*), thereby bringing out the fact that more light helped to reduce the LAI and vice versa.

Tiller production. The tiller production at different stages as influenced by the sowing months for Vijaya (Fig. 4) shows that the total tillers at the active and maximum tillering stages were lower in the December and January sowings and at a maximum in the June and July sowings. This low production may be due to the law minimum temperature at the vegetative phase (Fig. 3), as reported by VERGARA (1970). It can also be seen that the tiller number decreased from the maximum tillering stage onwards to a greater extent in the June and July sowings. Poor light conditions at the reproductive and ripening phases (Fig. 6) accompanied by a comparatively high night temperature might have led to less net photosynthesis, resulting in more deaths among the tillers (TANAKA *et al.* 1964) after this stage.

Dry matter production at flowering. Maximum dry matter production was obtained in the August sowing (Table 1), followed by the January sowing in both the years. Intermittent irrigation plots were superior in dry matter production because of the higher number of tillers in those plots in most of the sowings (Fig. 5). There is not much numerical difference in dry matter production between 3 of the varieties, Jayanthi, Ratna and Vijaya, though the lowest dry matter production was recorded in Bala, because of its shortness compared to the other cultivars. From an examination of dry matter production and tiller production at flowering (Fig. 4) it could be seen that the former followed more or less the same pattern as that of the latter. The minimum temperature during the reproductive phase was lowest in the August sowing (Fig. 3), resulting in the lowest respiration and more photosynthetic accumulation, leading to high dry matter production at flowering. The lowest dry matter production in the May and June sowings might be attributed to the lowest tiller number at flowering (Fig. 4) in these sowings.

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EFFECT OF TEMPERATURE ON THE PHYSIOLOGY AND BIOCHEMISTRY OF GERMINATING SEEDS OF *PHASEOLUS AUREUS* ROXB.

Temperature plays a critical role in seed germination. Although it is restricted to early imbibition, it is better expressed later during seedling development. Temperature has a direct effect on germination and dormancy and an indirect effect on future development (WENT 1953). Temperature also affects the seed leachate composition, which has been suggested as providing a rough estimation of seed viability (ABDUL BAKI—ANDERSON 1970, HAYMAN *et al.* 1960, SCHROTH 1966, TAKAYANAGI—MUNAKANI 1968). Many criteria have been put forward for judging the better germinability and vigour of seeds. These were primarily based on the time sequence of metabolic events (FRENCH 1959, GRABE 1964, WOODSTOCK 1969) and on the germination behaviour and external morphology of seedlings (MACGUIRE 1962, SHIBLES—MACDONALD 1962, WOODSTOCK 1969). The purpose of this investigation was to determine the optimum temperature conditions for getting the best seedling growth of mung and also to test the validity of mobilization efficiency (SRIVASTAVA—KOONER 1972) as a criterion for testing seedling vigour. Although this study utilized mung beans, the findings may be applicable to other seeds too.

Healthy seeds of *Phaseolus aureus* Roxb., cultivar 24—2, were surface sterilized with 0.1% mercuric chloride for 2 min and thoroughly washed with distilled water before planting. Germination took place in the dark, under sterilized conditions, in Petri dishes (13 cm $\times$ 13 cm) lined with filter paper moistened with 15 ml of an antibiotic solution (Penicillin + Streptomycin 50 μg/ml sterilized water) as the imbibing medium. Temperatures of 20°, 30°, 35°, and 40 °C were controlled in incubators (0—50°C range). The experiments were replicated three times with 100 seeds per replicate.

Weighed seeds were put on moistened filter paper in Petri dishes to imbibe water for 6 hr. After imbibition the seeds were reweighed after the blotting of surface moisture. The imbibition percentage was calculated on the basis of original weight. Seed germination was recorded after 50 hr of incubation. Seeds producing a root 3 mm or longer were considered germinated. The length of 20 seedlings chosen at random from each replicate was measured in 50 hr old seedlings.

The dry weight, mobilization efficiency, total nitrogen, protein nitrogen and total free amino acids were determined in excised samples of cotyledons and embryonic axes after 50 hr of incubation. The dry weight was determined after drying the samples at 60° for 24 hr. Mobilization efficiency was determined by applying the formula:

$$\text{Mobilization efficiency} = 100 \cdot \frac{\begin{array}{c}\text{increase in the dry weight}\\ \text{of embryonic axes}\end{array}}{\begin{array}{c}\text{decrease in the dry weight}\\ \text{of the two cotyledons}\end{array}} \cdot$$

Fresh samples of cotyledon and axis were taken for the determination of free amino acids, and dried samples (dried at 60°C for 24 hr) for the determination of protein and total nitrogen. The liquid remaining after 50 hr of incubation was decanted from the Petri dishes under sterilized conditions, centrifuged at 4000 r.p.m. for 30 min, evaporated for 24 hr in a vacuum at 30 ± 1°C and the residue dissolved in up to 5 ml of water. One ml of the aliquots from these samples was used to determine the total nitrogen.

The total nitrogen and protein in the dried material were determined by the standard micro Kjeldahl method (PEACH—TRACEY 1955). The protein nitrogen was precipitated with 10% trichloroacetic acid. The free amino acids were extracted at 6°C for 24 hr with 25 ml of 90% ethanol. The residue was washed three-times with 5 ml ethanol to ensure complete extraction of the free-amino acids. The extracted samples were evaporated to dryness in a vacuum desiccator at 32 ± 1°C. These dried amino acid samples were made up to 1 ml volume with 90% ethanol. Amino acid separation was done by the two-dimensional paper chromatography method, using phenol saturated with water (4 : 1) in an ammoniacal atmosphere as the first solvent and n-butanol : acetic acid : water (4 : 1 : 5) as the second solvent. The chromatograms were dried at 32 ± 1°C for 24 hr and sprayed with 0.2% ninhydrin. The sprayed chromatograms were incubated at 60°C for 30 min to develop the colour. The quantitative estimation of amino acids was done by densitometry (THOMPSON—STEWARD 1951). The actual quantity of amino acids in mg was calculated by comparison with the standard curve.

There was an overall increase in imbibition, germination and seedling growth with the increase in temperature from 20°C to 35°C, followed by a decrease at 40°C (Fig. 1). The results (Fig. 1) indicated the maximum loss in dry weight as compared to the control (Table 1) in the cotyledon at 35°C, and the minimum at 20°C. The loss in cotyledon dry weight coincided with the maximum increase in axis dry weight at 35°C and the minimum at 20°C. The mobilization efficiency was lowest at 20°C and highest between 30—35°C. The maximum loss of total nitrogen in the cotyledons was recorded at 35°C, while their maximum accumulation in the axis was at 30—35°C. The nitrogen composition in the diffusate was greater at 20°C and 40°C than at 30°C and 35°C. The maximum accumulation of protein nitrogen in the cotyledons and the minimum in the axes was recorded at 20°C. At 35°C the protein nitrogen decreased most in the cotyledons and increased most in the axes (Fig. 1).

The free-amino acid status in the seeds at any stage reflects the extent or degree of protein hydrolysis in the cotyledons and the mobilization to the axes, as has also been demonstrated in *Phaseolus lunatus* (ABDUL BAKI—SRIVASTAVA 1973). The maximum accumulation of free-amino acids in the cotyledons was recorded at 35°C, which was only slightly more than at 20°C, 30°C or 40°C. Embryonic axes, on the other hand, registered a maximum accumulation of free-amino acids at 30°C, less at 35°C and the lowest at 20°C and 40°C (Fig. 1). The data on the accumulation of individual amino acids are shown in Table 2. The cotyledons showed maximum accumulation of threonine and leucine + isoleucine at 30°C and 35°C. Embryonic

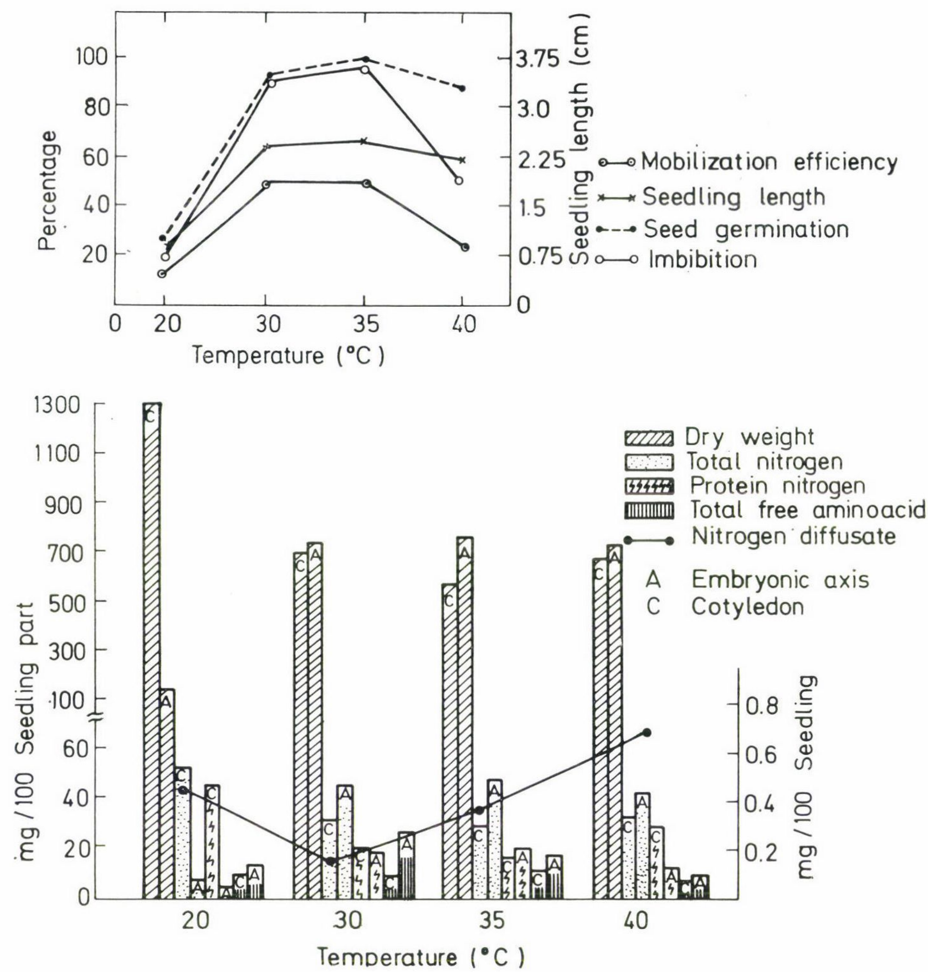

Fig. 1. Effect of different temperatures on various germination parameters and biochemical events in germinating seeds of *Phaseolus aureus* Roxb.

Table 1

Chemical analysis and dry weight (mg/100 seed parts) of cotyledons and embryonic axes excised from the seeds before imbibition

Character	Excised seed parts	
	Cotyledons	Axes
Dry weight	2050 ± 10	50 ± 2
Total nitrogen	91 ± 3	4 ± 0.5
Protein nitrogen	88 ± 2	2 ± 0.5
Total free-amino acid	1.8 ± 0.2	1.2 ± 0.1

Table 2

Free-amino acids (mg/100 seedling parts) in cotyledon pairs and embryonic axes of Phaseolus aureus seeds at different temperatures

Amino acids	Cotyledon/axes	Temperature (°C)			
	Before imbibition	50 hours after germination			
		20	30	35	40
Aspartic acid	0.11/0.07	0.90/0.90	0.37/1.10	0.47/0.30	0.35/0.22
Glutamic acid	0.08/0.01	0.06/0.15	0.02/0.05	0.01/0.01	0.01/0.15
Asparagine	0.36/0.09	0.07/0.61	0.06/3.10	0.07/1.50	0.25/0.15
Glycine + Serine	0.19/0.04	0.04/0.04	0.08/3.20	0.06/0.21	0.03/0.04
Alanine	0.06/0.14	0.01/0.03	0.02/0.04	0.03/0.15	0.02/0.02
Threonine	0.04/0.005	1.20/1.50	1.60/3.70	1.50/2.50	0.02/0.05
Tyrosine	0.00/0.00	0.77/0.17	0.75/4.00	0.77/2.20	0.40/1.40
Proline	0.39/0.00	0.77/0.77	0.77/0.30	0.77/2.20	1.07/1.60
Valine + Methionine	0.14/0.17	1.40/2.20	0.54/4.50	2.50/3.70	2.30/2.50
α-Amino butyric acid	0.16/0.01	0.08/1.10	0.04/2.20	0.04/0.44	0.07/0.07
Phenylalanine	0.05/0.04	0.00/2.00	0.00/0.00	0.00/0.00	0.00/0.90
Leucine + Isoleucine	0.16/0.00	2.50/2.60	3.20/4.50	2.90/3.70	2.10/1.80
Arginine + Lysine	0.001/0.08	0.004/0.008	0.95/0.90	0.95/2.10	0.05/0.00
Glutamine (0.0)	0.00/0.00	0.00/0.00	0.00/0.12	0.02/0.03	0.00/0.00
α-Alanine (0.0)	0.00/0.00	0.01/0.00	0.00/0.34	0.00/0.08	0.02/0.00

axes, on the other hand, showed the maximum concentrations of valine + methionine, asparagine, glycine + serine, threonine, tyrosine, leucine + isoleucine at 30°C and 35°C. A sharp increase in seedling length was observed at temperatures between 20°C and 30°C followed with a slight increase at 35°C and a decrease at 40°C (Fig. 1).

The temperature plays an important role in regulating the various physiological processes, from the early hours of imbibition to the germination and growth of the plants (Hoveland—Elkins 1965, Pollock—Toole 1966, Pollock 1969, Pollock *et al.* 1969). Both the percentage imbibition and the percentage germination increased with an increase in temperature from 20°C to 35°C. This may possibly be because of the increased permeability of the seed coat from the very beginning of imbibition till germination, confirming that the temperature of imbibition affects germination (Pollock—Toole 1966).

The maximum mobilization efficiency at temperatures of 30°C and 35°C corresponds with the maximum germination percentage at 50 hours. The mobilization efficiency at 20°C and 40°C was quite low, parallel with the poor germination behaviour at these temperatures. The lower mobilization efficiency at 20°C and 40°C may be the result of slow metabolic processes, parallel with cell division and cell elongation in the axis, which is supported by our findings with regard to the changes in dry weight, relative amounts of protein nitrogen, total nitrogen and free-amino acids in the cotyledons and axes (Fig. 1, Table 2). The lower mobilization efficiency at 20°C and 40°C can also be accounted for by increased membrane permeability to metabolites by means of its destruction, thus recording their relatively high concentration in the leachate as compared to those collected at 30°C and 35°C.

The presence of maximum amounts of threonine and leucine + isoleucine in the cotyledons at 30°C and 35°C (Table 2) suggests that they are released in greater quantity after protein hydrolysis. Their presence in the axes in a higher quantity suggests their rapid mobilization and low utilization in synthesis. The presence of valine + methionine, asparagine, glycine + serine and tyrosine in the axes in a quantity higher than in the cotyledons at 30°C and 35°C (Table 2) also suggests the possibility of their greater mobilization from the cotyledons to the axes. The high amount of asparagine in the axes at 30°C and 35°C suggests the possibility of reduced ammonia toxicity by means of its incorporation in the synthesis of asparagine from aspartic acid.

When germination and seedling growth are correlated with the physiological and biochemical parameters used in this study, it becomes evident that the mobilization efficiency, which is the resultant outcome of all the biochemical transformations, can give a real evaluation of seedling vigour. The better mobilization efficiency at 30°C and 35°C was in good agreement with the better seed germination and seedling development.

These data support the hypothesis presented earlier by the authors (Srivastava—Kooner 1972) that the mobilization efficiency may provide an additional criterion for judging seed vigour.

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THE EFFECT OF FOLIAR SPRAY WITH UREA AND AMMONIUM NITRATE ON GROWTH, YIELD, YIELD COMPONENTS AND SOME CHEMICAL CHARACTERISTICS OF MAIZE (ZEA MAYS, L.)

In the Arab Republic of Egypt maize is considered as one of the main cereal crops and is cultivated to face the increasing demand by the population for food. The possibility of adding more land to the arable area is limited. Therefore, a vertical expansion in agriculture, which can be performed by several means such as fertilization, is very necessary. Under local conditions, maize proved to respond well to nitrogenous fertilizers. The pattern of growth and nutrient uptake by maize plants as affected by N application has been studied by many investigators. HAY *et al.* (1953) reported that during grain development in maize, approximately 60% of the total N in the grain is translocated from the vegetative organs. This finding confirms the importance of adding N to maize plants before tasselling. KLINGMAN (1957) stated that the application of 40 lb/acre urea or ammonium nitrate gave the same maize yield as 80 lb/acre. VERMA—SINGH (1971) found that an increase in N application from 0 to 150 kg N/ha increased the average grain yield from 0.97 to 3.07 t/ha, while a further increase in N application decreased the grain yield. CHAN *et al.* (1972) reported that N application during the vegetative period increased the dry matter yield per plant. KRZYSCH—EBERHARDT (1960) reported that urea can be foliar sprayed on field crops without causing any harmful effect. WEISS (1967) reported that foliar spraying with N on maize plants had no effect on the maize yield. I'SO—HUSSIEN (1968) stated that foliar spraying with urea significantly increased the maize yield as compared with the unfertilized treatment. On the other hand, foliar spraying with ammonium nitrate in the same equivalent concentration showed harmful effects on the plant leaves and significantly decreased the maize yield. From the average of three years of experiments, KÁPOSZTA (1969) reported that foliar fertilization with urea, whether on a fertilized or non-fertilized basis, exerted no reliable yield increasing effect. Spraying on a single occasion or twice gave practically the same results. The leaves of maize plants were highly damaged by a 2% urea solution, and it also negatively affected the maize yield. The leaf damaging effect of a 1.5% urea solution was less.

This study was performed to investigate the effect of foliar spraying with urea and ammonium nitrate on growth, yield, yield components and some chemical characteristics of maize (*Zea mays*, L.) under the environmental conditions of El-Minia. Treatments with N as soil application have been involved.

A field experiment was conducted during the 1972 and 1973 seasons at the Experimental Farm of the Faculty of Agriculture, El-Minia University. A completely randomized technique with 8 treatments together with a control replicated 4 times was adopted for this study. The fertilizer treatments studied were as follows:

Table 1

Mechanical and chemical

Depth, cm	pH (1 : 2.5)	E.C. mmhos/	O.M. %	Total N %	$CaCO_3$ %	C.E.C. me/100 g soil
0—20	7.90	1.69	1.72	0.082	2.16	39.95

1. Control.
2. Foliar spraying with 1% urea solution at the rate of 48 kg N/ha (U_1).
3. Foliar spraying with 1% urea solution at the rate of 72 kg N/ha (U_2).
4. Foliar spraying with 1% urea solution at the rate of 96 kg N/ha (U_3).
5. Foliar spraying with 1% urea solution at the rate of 120 kg N/ha (U_4).
6. Foliar spraying with 1% ammonium nitrate solution at the rate of 48 kg N/ha (A_1).
7. Foliar spraying with 1% ammonium nitrate solution at the rate of 72 kg N/ha (A_2).
8. Foliar spraying with 1% ammonium nitrate solution at the rate of 96 kg N/ha (A_3).
9. Foliar spraying with 1% ammonium nitrate solution at the rate of 120 kg N/ha (A_4).

The foliar spraying was conducted twice. One half of the required solution was sprayed before tasselling and the other half was sprayed before silking.

Representative soil samples from the surface layer of the experimental field were air-dried, sieved through a 2-mm sieve and analyzed for pH, E.C., organic matter %, total N %, $CaCO_3$ %, C.E.C., exchangeable cations, and available P by Olsen's method, and a mechanical analysis was carried out. The afore-mentioned analyses were carried out according to the methods described by Piper (1950), Olsen *et al.* (1954) and Jackson (1958). The results of soil analysis are presented in Table 1.

The soil was ploughed and the field was ridged 60 cm apart. Each plot (5×5 m) consisted of 8 rows 5 m long. The maize (*Zea mays*, L.) double cross hybrid Giza 67 was planted as Nili planting at a distance of 50 cm. Three maize grains were cropped per hill. At the five-leaf stage the plants were thinned to one plant per hill. Before harvesting measurements of the plant height were recorded. The plots were harvested at the end of October and the yield and yield components were recorded. Representative samples of ground grains, straw and cobs were wet ashed using H_2SO_4 and H_2O_2. The digest was finally used to determine the total nitrogen by the Kjeldahl method described by Chapman—Pratt (1961). Phosphorus was photometrically determined according to Lepper (1950). All values of yield and chemical analysis were calculated on a 15.5% moisture basis. All the data were statistically analyzed as described by Snedecor (1956).

Yield and yield components. The results of the effect of foliar spraying with urea and ammonium nitrate on the yield and yield components of maize for the two seasons studied are presented in Table 2. The data proved that the maize yield responded well to foliar spraying with a 1% urea solution at the rate of 96 kg N/ha (U_3). With this treatment the maize yield significantly increased over the control and showed a yield response of 22.96% in the two seasons studied. Foliar spraying with the other urea treatments studied increased the maize yield, but the increase was insignificant. On the other hand, foliar spraying with 1% ammonium nitrate solutions exerted no reliable yield increasing effect. The maize yield decreased, but insignificantly, after foliar spraying with ammonium nitrate solution at rates of 96 and 120 kg N/ha (A_3, A_4). This may be due to the harmful, leaf-damaging effect of this solution at such high rates of application. These results are in good agreement with those obtained *analysis of the soil samples*

Exchangeable cations me/100 g soil				Available P p.p.m.	Mechanical analysis			Texture grade
Na^+	K^+	Ca^{++}	Mg^{++}		Sand %	Silt %	Clay %	
1.64	2.19	26.70	9.42	12.6	27.1	31.8	41.1	Clay loam

Table 2

The effect of foliar spraying with urea and ammonium nitrate on the yield and yield components of maize in the 1972 and 1973 seasons

Treatment	Plant height, cm	Number of plants*	Number of injured plants/plot	Number of barren plants/plot	Number of ears/plot	Yield** kg/plot	Yield response, %	Ear length, cm	Ear diameter, cm	1000-grain** weight, g
1972										
Control	286.3	69.8	0.0	6.5	74.8	13.02	—	17.50	3.91	301.05
U_1	302.0	71.3	0.0	3.5	80.5	14.37	10.37	18.05	4.10	306.18
U_2	300.8	69.8	1.0	1.8	83.0	15.12	16.13	18.58	4.08	314.25
U_3	311.8	68.0	2.0	1.8	85.8	16.01	22.96	18.93	4.21	316.75
U_4	293.8	69.3	2.5	2.8	80.8	13.80	5.99	18.00	3.90	307.85
A_1	303.3	69.3	1.8	2.5	80.0	14.12	8.45	17.98	3.98	305.50
A_2	298.3	69.8	2.3	1.8	77.5	13.49	3.61	18.00	4.00	305.25
A_3	290.8	65.8	2.5	2.8	75.3	12.82	−1.54	17.43	3.90	301.50
A_4	288.0	66.0	3.0	2.5	71.0	11.83	−9.14	16.83	3.75	285.81
L.S.D. 5%	21.3	3.8	0.8	3.0	5.0	3.21		1.10	0.21	12.75
1973										
Control	224.3	67.5	0.0	8.8	79.3	12.52	—	16.20	3.49	236.90
U_1	242.3	67.8	1.0	4.8	80.8	13.98	11.66	16.81	3.73	244.71
U_2	243.5	67.5	1.0	2.5	84.0	14.20	13.42	17.32	3.75	256.12
U_3	250.3	69.0	1.8	2.8	83.3	15.35	22.60	18.12	3.73	258.60
U_4	244.0	68.5	2.8	4.0	81.5	13.12	4.49	16.43	3.64	247.28
A_1	238.8	67.0	1.8	5.0	79.8	13.64	8.95	16.48	3.70	249.35
A_2	233.5	67.3	2.3	5.5	79.3	13.48	7.67	16.10	3.53	235.81
A_3	230.3	65.5	3.0	6.0	78.0	12.48	−0.32	16.32	3.55	237.10
A_4	228.0	66.8	4.0	5.5	74.0	11.10	−11.34	15.21	3.43	222.42
L.S.D. 5%	20.5	4.3	1.5	3.3	3.8	2.51		1.20	0.16	13.13

* Plot = 25 m^2
** Calculated on a 15.5% moisture basis

Table 3a

The effect of foliar spraying with urea and ammonium nitrate on the chemical composition of maize, N-uptake and % N derived from foliar fertilization (1972 season)

Treatments		Yield** kg/plot	N, %	N-uptake, g/plot	N given as foliar spray, g/plot	Increase in N-uptake over control, g/plot	% N derived, from foliar fertilization	P %	P-uptake, g/plot	K %	K-uptake, g/plot
Control	grains	13.02	1.22	158.84				0.35	45.57	0.26	33.85
	straw	6.29	0.47	29.56				0.09	5.66	0.77	48.43
	cobs	3.38	0.29	9.80				0.03	1.03	0.41	13.86
	Total	22.69		198.20	—	—	—		52.24		96.14
U_1	grains	14.37	1.46	209.80				0.37	53.17	0.27	38.80
	straw	7.25	0.49	35.53				0.09	6.53	0.97	70.33
	cobs	3.74	0.30	11.22				0.03	1.12	0.41	15.33
	Total	25.36		256.55	116.78	58.35	49.97		60.82		124.46
U_2	grains	15.12	1.47	222.26				0.37	55.95	0.29	43.85
	straw	7.63	0.49	37.39				0.09	6.87	0.88	67.14
	cobs	3.95	0.30	11.85				0.03	1.19	0.40	15.80
	Total	26.70		271.50	178.58	73.30	41.17		64.01		126.79
U_3	grains	16.01	1.49	238.55				0.39	62.44	0.30	48.03
	straw	7.75	0.51	39.53				0.10	7.75	0.99	76.73
	cobs	4.19	0.30	12.57				0.03	1.26	0.41	17.18
	Total	27.95		290.65	238.10	92.45	38.83		71.45		141.94

U_4	grains	13.80	1.44	198.72				0.35	48.30	0.27	37.26
	straw	6.67	0.48	32.02				0.09	6.00	0.95	63.37
	cobs	3.59	0.29	10.41				0.03	1.08	0.40	14.36
	Total	24.06		241.15	297.63	42.95	14.43		55.38		114.99
A_1	grains	14.12	1.46	206.15				0.37	52.24	0.27	38.12
	straw	6.82	0.49	33.42				0.10	6.82	0.97	66.15
	cobs	3.68	0.30	11.04				0.03	1.10	0.41	15.09
	Total	24.62		250.61	116.78	52.41	44.88		60.16		119.36
A_2	grains	14.12	1.46	206.15				0.37	52.24	0.27	38.12
	straw	6.49	0.47	30.50				0.09	5.84	0.87	56.46
	cobs	3.50	0.29	10.15				0.03	1.05	0.41	14.35
	Total	23.48		237.60	178.58	39.40	22.06		56.80		109.93
A_3	grains	12.82	1.41	180.76				0.35	44.87	0.27	34.61
	straw	6.13	0.45	27.59				0.09	5.52	0.85	52.11
	cobs	3.33	0.29	9.66				0.03	1.00	0.41	13.65
	Total	22.28		218.01	238.10	19.81	8.32		51.39		100.37
A_4	grains	11.83	1.41	166.80				0.35	41.41	0.27	31.94
	straw	5.44	0.45	24.48				0.09	4.90	0.85	46.24
	cobs	2.96	0.29	8.58				0.03	0.89	0.41	12.14
	Total	20.23		199.86	297.62	1.66	0.56		47.20		90.32
L.S.D. 5%	grains	3.21	0.21					0.03		0.02	
	straw	1.20	0.03					0.01		0.11	
	cobs	0.42	0.02					0.01		0.05	

* Plot = 25 m^2 ** Calculated on a 15.5% moisture basis

Table 3b

The effect of foliar spraying with urea and ammonium nitrate on the chemical composition of maize, N-uptake and % N derived from foliar fertilization (1973 season)

Treatments		Yield** kg/plot	N %	N-uptake, g/plot	N given as foliar spray	Increase in N-uptake over control, g/plot	% N derived from foliar fertilization	P %	P-uptake, g/plot	K %	K-uptake, g/plot
Control	grains	12.52	1.31	164.01				0.39	48.83	0.13	38.81
	straw	5.96	0.49	29.20				0.11	6.56	0.82	48.87
	cobs	3.24	0.31	10.04				0.04	1.30	0.44	14.26
	Total	21.72		203.25	—	—	—		56.69		101.94
U_1	grains	13.98	1.57	219.49				0.42	58.72	0.33	46.13
	straw	6.75	0.51	34.43				0.11	7.43	1.04	70.20
	cobs	3.63	0.33	11.98				0.04	1.45	0.44	15.97
	Total	24.36		265.90	116.78	62.65	53.65		67.60		132.30
U_2	grains	14.20	1.62	230.04				0.41	58.22	0.37	52.54
	straw	6.89	0.50	34.45				0.11	7.58	0.97	66.83
	cobs	3.70	0.33	12.21				0.04	1.48	0.44	16.28
	Total	24.79		276.70	178.58	73.45	41.13		67.28		135.65
U_3	grains	15.35	1.61	247.14				0.44	67.54	0.39	59.87
	straw	7.49	0.54	40.45				0.13	9.74	1.10	82.39
	cobs	4.01	0.33	13.23				0.05	2.01	0.44	17.64
	Total	26.85		300.82	238.10	97.57	40.98		79.29		159.90

U_4	grains	13.12	1.45	194.18				0.39	51.17	0.33	43.30
	straw	6.34	0.49	31.07				0.11	6.97	0.99	62.77
	cobs	3.41	0.31	10.57				0.04	1.36	0.43	14.66
	Total	22.87		235.82	297.62	32.57	10.94		59.50		120.73
A_1	grains	13.64	1.56	212.78				0.41	55.92	0.33	45.01
	straw	6.59	0.51	33.61				0.12	7.91	1.00	65.90
	cobs	3.54	0.33	11.68				0.04	1.42	0.44	15.58
	Total	23.77		258.07	116.78	54.82	46.94		62.25		126.49
A_2	grains	13.45	1.58	212.98				0.41	55.27	0.35	47.18
	straw	6.54	0.50	32.70				0.11	7.19	0.92	60.17
	cobs	3.51	0.31	10.88				0.04	1.40	0.44	15.44
	Total	23.53		256.56	178.58	53.31	29.85		63.86		122.79
A_3	grains	12.48	1.41	175.97				0.39	48.67	0.33	41.18
	straw	6.00	0.46	27.60				0.11	6.60	0.85	51.00
	cobs	3.23	0.31	10.01				0.04	1.29	0.43	13.89
	Total	21.71		213.58	238.10	10.33	4.34		56.56		106.07
A_4	grains	11.10	1.43	158.73				0.39	43.29	0.30	33.30
	straw	5.31	0.46	24.43				0.11	5.84	0.85	45.14
	cobs	2.87	0.32	9.18				0.04	1.15	0.43	12.34
	Total	19.28		192.34	297.62	10.91	0.00		50.28		90.78
L.S.D. 5%	grains	2.51	0.22					0.04		0.03	
	straw	0.92	0.04					0.01		0.16	
	cobs	0.25	0.02					0.01		0.03	

* Plot = 25 m^2 ** Calculated on a 15.5% moisture basis

by I'so—Hussien (1968). The relatively high maize yields obtained for the control in this experiment might be due to the effect of the preceding legume crop and the high fertile potentiality of the experimental soil. This is confirmed by the results obtained by Hamissa *et al.* (1971), who found that average maize yields in Middle Egypt were always higher than those in the Delta.

Plant height, number of ears per plot, ear length, ear diameter and 1000-grain weight showed the same trend as the maize yield. For all the afore-mentioned components, a significant increase was obtained by foliar spraying with a 1% urea solution at the rate of 96 kg N/ha (U_3). On the other hand, the number of barren plants was reduced by foliar fertilization; the decrease was significant after foliar spraying with a 1% urea solution. With respect to the leaf-damaging effect of foliar spraying, the general trend of the results showed that the number of injured plants increased as the rate of foliar application increased, especially with ammonium nitrate solution. These results are in good agreement with those obtained by I'so—Hussien (1968) and Káposzta (1969). The results revealed no significant effect of the treatments studied on the number of plants per plot.

Chemical composition and N-uptake. The effect of foliar spraying with urea and ammonium nitrate on the chemical composition of maize, the N-uptake and the % N derived from foliar fertilization for the two seasons studied are given in Tables 3a and 3b. The results revealed that the N, P and K % in the grains and straw significantly increased after foliar spraying with a 1% urea solution at the rate of 96 kg N/ha (U_3), while in the cobs no significant effect was recorded. Latkovics (1962), Hussien (1969) and Verma *et al.* (1972) found that by increasing the nitrogen fertilizer levels to maize plants, the N% in the leaves, stalks and grains significantly increased, but in the cobs no significant effect was remarked. Regarding the results of N-, P- and K-uptake, it is obvious that the highest values in the seasons studied were obtained by foliar spraying with a 1% urea solution at the rate of 96 kg N/ha (U_3), while the lowest values were obtained by foliar spraying with a 1% ammonium nitrate solution at the rate of 120 kg N/ha (A_4). P- and K-uptake were increased by increasing N-uptake. These results are in good agreement with those obtained by Debreczeni (1961), Krámer—Pekáry (1962), Latkovics (1962) and Hussien (1969), who reported that P- and K-uptake are positively correlated with N-uptake.

It is worth mentioning that the percentage N derived from foliar fertilization was reduced on increasing the rate of N application. With urea treatments the decrease was from 49.97 to 14.43% and from 53.65 to 10.94%, respectively, in the two seasons studied. With ammonium nitrate treatments the decrease was from 44.88 to 0.56% and from 46.94 to 0.0%, respectively in the two seasons studied. This may be due to the harmful effect of foliar spraying with high N rates on plant growth. Also, the increase in N-uptake is not proportional to the increase in N applied as foliar fertilization. Krámer—Pekáry (1962) found that by increasing the rate of N fertilizers, the percentage N derived by the plants decreased from 64 to 7%, however, this differs from year to year and from one location to another. This is confirmed by our results.

Therefore, according to the results obtained, foliar spraying with a 1% urea solution at the rate of 96 kg N/ha could be recommended for fertilizing maize plants.

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EVALUATION OF VARIOUS ZINC SOURCES FOR MAIZE AND WHEAT

Among the micronutrients, Zn is the most limited nutrient in the soils of the world (THORNE 1957) and of India (RANDHAWA—TAKKAR 1975). The recognition of widespread Zn deficiency in crops has created considerable interest in materials suitable for use as Zn fertilizers. Although soil application of Zn has been found to be the most efficient method for correcting the deficiency condition (TAKKAR *et al.* 1974), yet with the increasing need for Zn in soils, more economical and equally effective sources of Zn are required. Keeping this in view the present investigation was undertaken to study the relative efficiency of various Zn sources for maize and wheat crops in rotation.

A greenhouse experiment was conducted on a Fatehpur loamy sand soil (Ustipsamments). The soil pH was 8.2 and the electrical conductivity 0.2 mmhos/cm in a 1 : 2 soil water suspension. The contents of $CaCO_3$ and organic carbon (O.C.) were 0.3 and 0.06%, respectively. The available phosphorus (Olsen's P) was 10 kg P_2O_5/ha. The available Zn, Cu, Fe and Mn (measured by the DIPA method, LINDSAY—NORVELL 1969) were 0.32, 0.40, 4.8 and 6.0 ppm, respectively. Polythene-lined earthern pots were filled with 3 kg soil, sieved through a 2 mm screen. A basal application of 120 ppm N, 60 ppm P_2O_5 and 60 ppm K_2O were given to each pot. Zinc sulphate (23% Zn), zinc acetate (29.8% Zn), zinc oxide (78.0% Zn), zinc dross (90.0% Zn), a by-product of the galvanizing industry, zinc frits (16.0% Zn), manufactured by Ferro Coatings and Colours Ltd., Parganas, W. Bengal (India), and NU-spartin (5.7% Zn), a multi-micronutrient compound manufactured by Swati Industries Private Ltd., Bombay (India) were the sources investigated. Zinc from each source was applied at the rate of 1.25, 2.5 and 5.0 ppm Zn. Three replications were provided, in a completely randomized block design. Deionized water was used for irrigation. The maize variety Ganga 5 was grown and harvested after 45 days. The soil of each pot was then dried and screened through a 2 mm sieve to remove maize roots. After applying a basal dose of 120 ppm N, 60 ppm P_2O_5 and 60 ppm K_2O, the soils were thoroughly mixed on a polythene sheet and put back into the same pots. The residual effect of different Zn sources and their Zn levels was studied on wheat variety WG 357, which was grown up to maturity. Samples of grain and straw were taken. The plant samples were washed successively with 0.1 N HCl, distilled water and deionized water, and oven dried at 70°C. The samples were ground in a Braun mixer with stainless steel blades. The samples were wet ashed with a HNO_3—H_2SO_4—$HClO_4$ ternary acid mixture (9 : 1 : 3). The zinc in the plant extract was estimated by atomic absorption spectrophotometry. The relative efficiency of various zinc sources at different rates of Zn application was calculated by taking zinc sulphate as the standard source and equating the percentage response of zinc sulphate to one. The Bray's percentage yield was worked out as follows:

$$\text{Bray's percentage yield} = \frac{\text{Yield without Zn application}}{\text{Yield with optimum application}} \times 100$$

The Bray's percentage uptake was also calculated according to the same formula.

Maize yield and uptake response. The results on yield, Zn-uptake and Zn concentration in maize are shown in Fig. 1 and Table 1. There was a significant increase in yield as a result of the application of all the Zn carriers investigated. Zinc sulphate and zinc acetate (highly water soluble sources) at a 2.5 ppm Zn rate were significantly better than other sources, but at a 5.0 ppm Zn rate these carriers and also Zn dross (water insoluble source) were significantly better than zinc frits and NU-spartin. The maize yield and Zn- uptake in the absence of Zn application were 77.4 to 96.7% and 37.2 to 59.2% of the maximum, respectively. The rest of the yield (3.3 to 22.6%) and Zn uptake (40.8 to 62.8%) were attributed to the differential response of maize to Zn application from various sources. The maximum increase in yield was obtained from the application of zinc sulphate, followed by zinc acetate and the least with zinc frits.

A significant increase in maize yield resulted from the significant increase in Zn concentration in the plants due to the application of different Zn sources (Fig. 1, Table 1). Zinc concentration in plants grown in the check pot was 12.3 ppm, whereas with Zn application it varied from 19.0 to 27.8 ppm. This indicates that the Zn content of plants from the check pot was lower than the critical level (20 ppm Zn; JONES 1972, RANDHAWA—TAKKAR 1975), suggesting that the response to Zn application was expected. Also, the maximum increase in Zn uptake (0.34 mg/pot) by the maize was obtained from zinc sulphate application and the least with NU-spartin (0.13 mg/pot). This shows that Zn applied as zinc sulphate was more

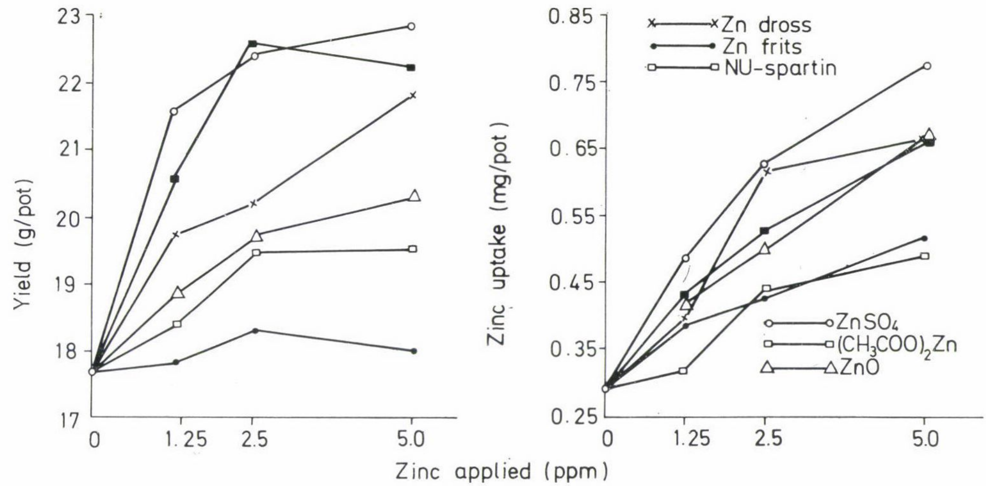

Fig. 1. Dry matter yield and Zn-uptake by maize as influenced by sources and levels of Zn. LSD (yield and Zn uptake) at 0.05 for source means, 2.5 and 0.08; for levels within sources, 1.1 and 0.14

Table 1

Effect of rates of Zn applied from different sources on the Zn concentration, Bray's percentage yield and Bray's percentage Zn- uptake in maize

Sources	Levels of Zn applied (ppm)				Bray's percentage yield	Bray's percentage uptake
	1.25	2.5	5.0	Mean		
			Zn concentration (ppm)			
$ZnSO_4$	22.5	27.2	33.7	27.8	77.4	37.2
$(CH_3COO)_2Zn$	20.8	22.8	29.8	24.5	78.6	43.9
ZnO	22.2	26.2	33.3	27.2	87.2	43.3
Zn dross	22.3	29.7	30.7	27.6	81.2	43.9
Zn frits	21.3	23.7	29.2	24.7	96.7	55.8
NU-spartin	17.3	19.7	20.0	19.0	90.6	59.2
Control				12.3		

L.S.D. at P = 0.05
For comparing any two source means = 2.4
For comparing any two levels within zinc source = 4.1

readily utilized by the plants than from other sources. The superiority of zinc sulphate over other sources is due to its high water solubility. BARNETTE (1936) also reported that Zn-deficient maize, grown on sandy soils in Florida, responded better to zinc sulphate than to zinc oxide. The relative efficiency of the Zn sources investigated are shown in Fig. 2 and their order of efficiency is: zinc sulphate, zinc acetate, zinc dross, zinc oxide, NU-spartin and zinc frits.

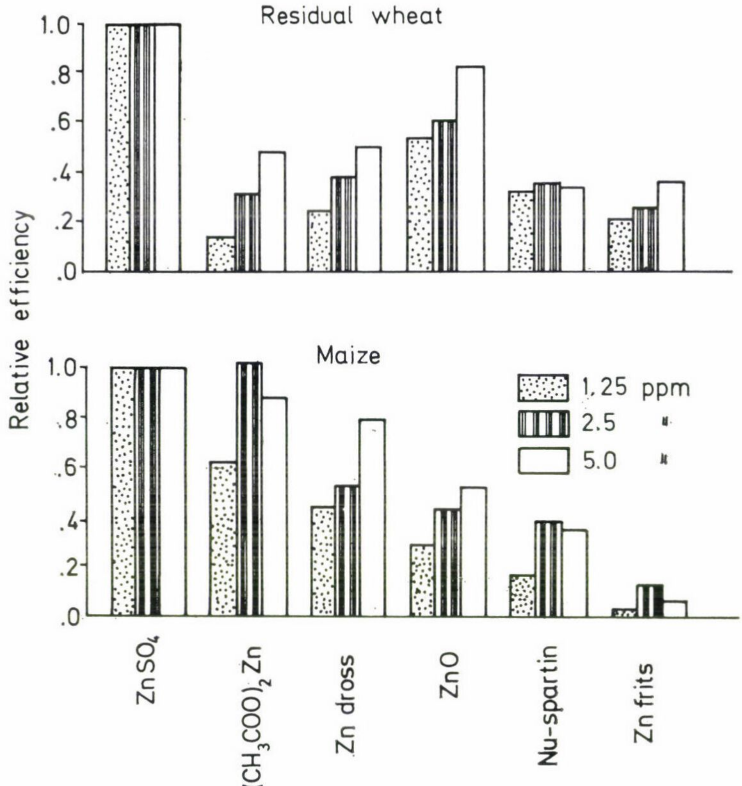

Fig. 2. Relative efficiency of different zinc sources for maize and wheat

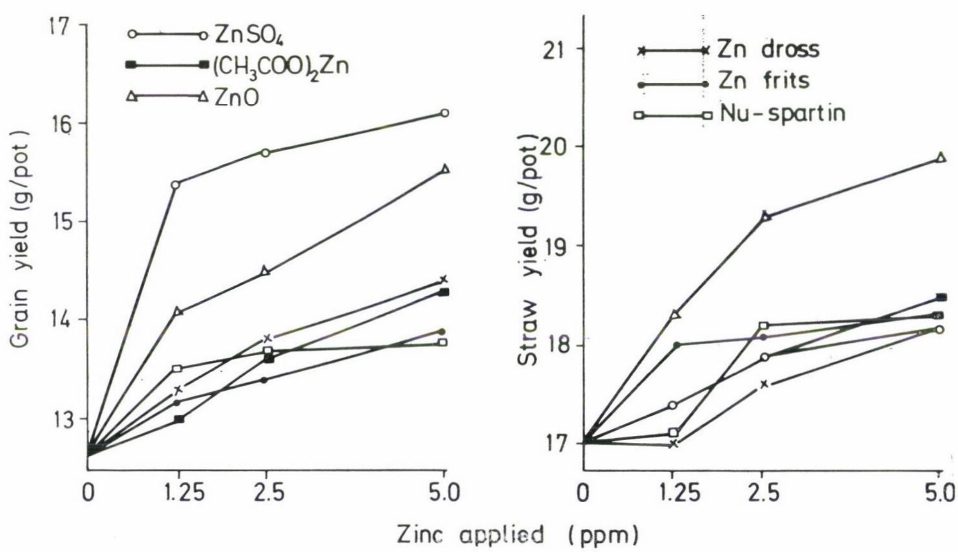

Fig. 3. Grain and straw yield of wheat as influenced by sources and levels of Zn. LSD (grain and straw) at 0.05 for source means 1.2 and NS; for levels within source 2.1 and NS

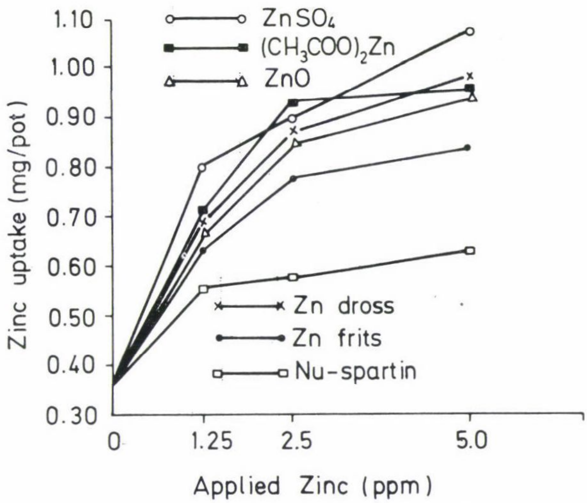

Fig. 4. Zn-uptake by wheat as influenced by sources and levels of Zn. LSD at 0.05 for source means 0.09; for levels with source 0.15

Table 2

The effect of residual levels of Zn from different sources on the Zn concentration, Bray's percentage grain yield and Bray's percentage Zn-uptake in wheat

Sources	Levels of Zn (ppm)				Levels of Zn (ppm)				Bray's percentage	
	1.25	2.5	5.0	Mean	1.25	2.5	5.0	Mean	Grain yield	Zinc-uptake
	Grain Zn concentration				*Straw Zn concentration*					
$ZnSO_4$	34.0	36.0	40.3	36.8	16.2	19.2	23.0	19.5	78.3	33.6
$(CH_3COO)_2Zn$	36.7	39.5	38.3	38.2	13.8	18.5	23.5	18.6	88.0	37.5
ZnO	29.8	35.0	36.7	33.8	13.7	18.0	19.0	16.9	81.3	37.9
Zn dross	30.3	34.2	41.0	35.2	16.5	22.5	28.2	22.4	89.5	39.4
Zn frits	27.3	31.3	34.2	30.9	15.8	20.2	20.0	18.7	90.6	42.9
NU-spartin	28.7	31.5	34.2	31.5	7.0	8.5	8.0	7.8	91.8	57.1
Control				16.8				6.5		

L.S.D. at P = 0.05 *Grain* *Straw*
For comparing any two levels source means = 2.5 2.9

For comparing any two within zinc source = 4.4 5.1

Yield and uptake response of wheat to residual zinc. The data on the residual effect of different Zn sources on wheat yield, Zn-uptake and Zn concentration are presented in Figs 3 and 4 and Table 2. The results indicate a significant increase in grain yield and a non-significant increase in straw yield. The maximum increase in grain yield was obtained at a 5 ppm Zn rate with all the Zn sources tested. The residual effect of zinc sulphate, zinc oxide and zinc dross gave significantly higher grain yields than other sources. The grain yields in the absence of Zn treatments were 78.3 to 91.3% of the maximum. The rest of the yield (8.7 to 21.7%) was due to a differential wheat response to Zn application from various sources. Here too, residual Zn from zinc sulphate gave the maximum grain yield (21.7% response) and NU-spartin the least (8.7% response).

The significant response of wheat to Zn is the result of a significant increase in both grain and straw Zn concentration due to the application of different sources. MEELU—RANDHAWA (1970) also reported that the Zn content increased with the application of zinc sulphate and zinc oxide in wheat.

The total Zn-uptake by wheat also increased significantly as a result of Zn application, the increase being maximum with zinc sulphate, followed by zinc acetate, zinc dross, zinc oxide, zinc frits and NU-spartin application. Zinc-uptake in the absence of Zn application varied from 33.6 to 57.1% of the maximum, indicating that 42.9 to 66.4% Zn-uptake is due to Zn availability from various sources. The maximum increase in Zn-uptake was observed due to zinc sulphate (0.56 mg/pot) and the least with NU-spartin treatment (0.23 mg/pot). Apparently, the Zn in zinc oxide and zinc dross was utilized as readily as that in zinc acetate and zinc sulphate by the second crop of wheat. This indicates that zinc dross has some prospect of being used as a source of Zn. The utilization of Zn from water insoluble materials was comparable to that from water soluble materials. The data also show that the Zn from zinc frits and NU-spartin was not efficiently utilized by maize and wheat. These observations agree with those of BOAWN *et al.* (1957) who found that zinc frits was inferior to a number of other sources, including zinc oxide and zinc sulphate, for sorghum. The order of relative efficiency of different Zn sources (Fig. 2) is: zinc sulphate, zinc oxide, zinc dross, NU-spartin, zinc acetate and zinc frits. MEELU—RANDHAWA (1970) have also observed the superiority of zinc sulphate over zinc oxide and spartin.

This study suggests that zinc sulphate is the most efficient source amongst the different sources included in the present investigation.

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FORUM

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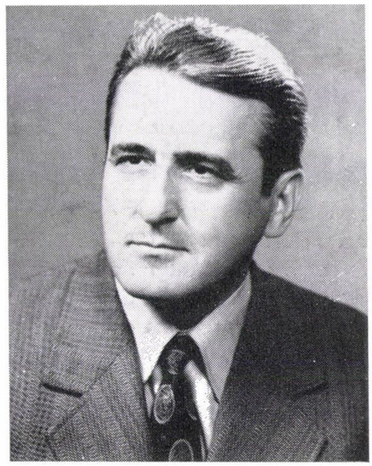

DR. PÁL ROMÁNY

MINISTER OF AGRICULTURE AND FOOD
OF THE
HUNGARIAN PEOPLE'S REPUBLIC

PÁL, GY.: *Sir!*

Due to the development of industry and transport the agricultural production area in Hungary decreased by 122,000 ha between 1960 and 1975. The extent of the reduction is almost equal to the total national sunflower area in 1975 (129,000 ha). Do you consider this 1.4 per cent reduction in the agricultural area over 15 years to be permissible, or should, in your opinion, any further decrease be prevented at all costs, even by administrative measures if necessary ?

ROMÁNY, P.: This problem has often been encountered in recent years. Some important measures have already been taken in this matter and I think a public view about land as an unmultipliable but vitally important treasure is slowly beginning to take shape. The simplest answer would be to say: yes, any further reduction in the agricultural area must be prevented at all costs, even by administrative measures if necessary. The situation is, however, somewhat more complicated.

In fact, the development of industry and transport was not the only factor responsible for the 122,000 ha reduction in the agricultural area between 1960 and 1975. Considerable areas were withdrawn from agricultural production for urban development (housing), mining water management, and for the construction of various agricultural establishments (livestock units, grain stores, etc.).

In most of the above cases the withdrawal of these areas from agricultural production was justified.

Parallel to the land requirements of the new investments and establishments being implemented in various branches of the national economy (e.g. the opencast coal and bauxite mines, the motorways, the petroleum and natural gas sources, etc. which are now in the planning stage or already under construction), the acreage available for agricultural production is likely to decrease in the future, too.

In spite of the fact that in recent years less agricultural area has been utilized than earlier (an average of 9 thousand hectares a year less between 1960 and 1970, and 6 thousand hectares a year less from 1971 to 1977), more economical land management is expected to be achieved, partly by paying higher compensation for the area used, and partly through stricter regulation and control of land use.

According to new legal provisions on the increased protection of land, high quality land particularly valuable for agricultural production (large-scale plots, vineyards, orchards and irrigation areas) can only be used for other purposes in exceptional cases, such, as e.g. in the case of investments fixed to a particular location (e.g. mines). If the use of such land is unavoidable, apart from compensation for the expropriation, the investor has to pay a considerable sum (50—250 thousand Ft/ha depending on the quality of the land) as extra compensation.

Financial interest will probably urge the investors to plan establishments partly on poorer quality lands, and partly to cover only as large an area as is absolutely essential.

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PÁL, GY.: *Supplying the population with fresh vegetables and fruits, as well as fulfilling export plans and satisfying the demands raised by the preserving industry, has lately become more and more difficult. Do you think that the large farms, which struggle with a labour shortage, or the household farms, which are scantily equipped with over-expensive small machines, will best be able to ensure the fresh vegetable and fruit supply of the population in addition to satisfying the demands raised by exporters and the preserving industry ?*

ROMÁNY, P.: Both in our production policy and in our product distribution and trade policy a different order of preference prevails. Keeping the population supplied with fresh and preserved fruit and vegetables is regarded as the primary task, and only produce in excess of this is exported either directly or in a preserved form. As a result of the recent acceleration in the technical development of large farms, vegetables can be produced in large volumes, far exceeding the domestic requirements, in spite of the labour problems. The preserving industries (including the canning industry) mostly export vegetables, which make up some 60—80% of their output.

The production of fruit and vegetables requiring a lot of manual labour is a more difficult question. These, too, need to be produced in larger quantities, but this requires wider collaboration across the social structure. Last year a programme was elaborated to this end, with government decisions made and measures taken to carry it through. The measures were concerned partly with the modernization of production, and partly with te improvement of the economic efficiency of production; besides large farms, they increasingly affect household plots and subsidiary farms. The result can already be seen in 1977 in favourable price trends and a better supply of goods.

Thus, the support of small producers parallel to constant improvement in large-scale fruit and vegetable production is an integral part of our agricultural policy. The small producers present share of 30% in vegetable and 55% in fruit production will continue to be of importance in the years to come. They play a highly important role in the production of crops based mainly on manual work (green paprika, cucumber, green peas in the pod, tomatoes for fresh consumption, strawberries, raspberries, sour cherries, etc.).

All in all, we have made and are making considerable efforts to improve the small machine supply of household plots and subsidiary farms, and to render their production and commodity sales more reliable and better organized. The two types of farms cannot be compared on the basis of technical levels alone, because household farming, owing to its special character, need not be mechanized to the same extent as large farms are. Not only large farms struggle with a labour shortage, and not only the small plot machines are expensive. If a "labour shortage" occurs in the household farm (there is a good programme on the television, or they have to go out for some reason, etc.), certain things will be left undone and the effect of this may be felt in just the same way.

To sum up, we do not wish to make the distinction suggested in the question. Let us enjoy what the household farms offer us as long as we can, but in the course of development, in laying the foundations for the future, and in mass commodity production we can only rely on large farms.

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PÁL, GY.: *In the historical wine regions of Hungary it is, as yet, impossible to cultivate high gradient areas mechanically. In order to replace the vine areas thus excluded from cultivation the large farms have planted vines on mechanically cultivable gentle slapes, so that the total vine area of the country has not changed. What plans do you and your ministry have for the steep vine areas which were previously under strip cultivation, but are now left fallow ?*

ROMÁNY, P.: The reduction of the vine area on household and subsidiary farms is not a problem which arises only in the historical wine regions; it is a nation-wide phenomenon. The abandonment of small vine plots on the hillsides is more problematic because the steep slopes can hardly be used either for vine growing or for any other kind of large-scale cultivation. The aesthetic aspects of barrenness on the higher slopes are not negligible either, not to mention the irreparable damage caused by soil erosion.

With a view to utilizing areas which were previously cultivated but are now lying fallow, it is our policy to urge the large-scale cultivation of steeper slopes and terraced areas. An attempt is made to find machine types adapted to narrow rows and to the load capacity of the supporting walls. The Badacsony State Farm has come closest to a solution, but these good practices are spreading.

The Ministry of Agriculture and Food is endeavouring to check the abandonment of cultivation areas on higher slopes, With this in view:

— The financial interest of small producers is being increased. In 1977 the state purchasing prices were 15% higher in hilly areas, and 23% higher in the Tokay district than they were in 1975.

— The supply of small farms with up-to-date, good quality machines is being improved, at te cost of a considerable financial sacrifice by the state. Small machines which replace hard physical work, but which cannot be economically manufactured in Hungary were purchased to the value of 1.3 million $ in 1976 and 4.2 million $ in 1977.

— State subsidies equal to those given to the large farms are granted to small producers who undertake to renew their vineyards on definite terms consistent with the production conditions of small producers. The extent of subsidization is 40% in general, and 70% for the steep slopes of the Tokay district.

Vine areas which are abandoned for good can be put to use, once they have been taking under public ownership, primarily through long-term leases,* or failing all else, by protective forest belt plantation.

* Currently world market prices show a sharp drop for a number of products and an increase for others.

PÁL, GY.: *The green revolution, which has greatly improved the nutrition level of the constantly increasing world population, has also pushed out of production the valuable domestic and local varieties which have lower productivity. At a time when international varieties are gaining ground everywhere, what importance do you attach to plant breeding in Hungary?*

ROMÁNY, P.: The question is rather extreme, but is nevertheless of current interest, and reflects one of the most urgent problems of mankind. The preservation of the gene basis of old varieties eliminated from production, and the use of this gene stock in breeding are tasks of primary importance. I do not take the situation too seriously. Why?

— In all countries with a developed agriculture great emphasis is laid on the preservation of plant stocks. A gene bank has been established and is being constantly improved in Hungary, as elsewhere; its function is to maintain, preserve and evaluate the varieties and local varieties eliminated from production, and to put this stock at the disposal of breeders.

— The gene banks of different countries exchange stocks free of charge, so the gene pool in these countries is growing from year to year.

— It is true that due to the dynamic progress in international variety exchange the poorer varieties of the different countries are being pushed into the background. This is, however, an essential element of development, in Hungary as elsewhere. It cannot be claimed, for example, that the Soviet Bezostaya 1 or the Italian Libellula have caused a reduction in our gene stock. On the contrary: since these varieties contributed greatly to an increase in the yield averages, they were widely used in wheat breeding, thereby increasing the gene stock of the new Hungarian wheat varieties. Nor can it be claimed that the Bánkuti wheats, among others, have not been preserved and can no longer play an important role in breeding by using up-to-date breeding techniques (e.g. induced gene mutation).

As for my opinion on the importance of plant breeding in Hungary, I can only say that agriculture, and more specifically plant growing, has always had a decisive role in Hungary, so that plant breeding will keep its importance. However, owing to the rapid development and rather frequent change of varieties breeders cannot be expected to meet all the demands at any time. The manifold and ever more differentiated demands which the varieties must meet can only be satisfied if the most valuable foreign varieties are introduced to complement the Hungarian breeding stock. This will also encourage Hungarian breeders to attain better and better results.

Breeding has wide perspectives even if for many plants sudden changes can hardly be expected using the present methods. I think that genetic research and the computerized storage of plant material collected in the gene bank are of great importance for the future. In this way it will be possible to select and combine the gene material according to current requirements.

Induced mutations and zygotes produced by methods other than natural reproduction offer the possibility of obtaining new forms. Gene surgery renders it possible to control the combinations.

Tissue cultures, as a vegetative means of reproduction, may become general, thereby making it possible to obtain clones from any plant.

All thus shows that we need not be afraid of the so-called green revolution, nor that plant breeders will having nothing to do. On the contrary, we are threatened by a different, though more pleasant danger. Similarly to the information explosion, breeding may result in such a mass of achievements that the choice of varieties most suitable for production may cause more difficulty than producing new ones. This, however, will be a problem for variety trials and variety qualification to solve.

PÁL, GY.: *In Hungary the average size of a state farm was 2914 ha in 1960, 5548 ha in 1970 and 6602 ha in 1975. The average area of a co-operative farm was 870 ha in 1960, 1985 ha in 1970 and 3161 ha in 1975. Considering the geographic and climatic conditions of Hungary, what, in your opinion, will be the rational farm size for state and co-operative farms in the future ?*

ROMÁNY, P.: As regards natural conditions, it is topographic features and other factors which affect plot sizes which play a decisive role in this respect rather than climatic conditions. Natural factors can only influence the dimensions of the various sections within a farm, and hardly affect the size of the farms themselves under Hungarian conditions.

From economic and management points of view farm size depends in practice on two factors:

a) on the technical level or the state of engineering and technical development (what the industrial background can provide)

and *b)* on the intellectual capacity and the standard of management (what size of operation the management is able to organize and keep in hand).

I do not think that the present level of technical development hinders the increase in farm size.

On the other hand, experience suggests that no new intellectual capacity, which would be a precondition for raising the standard of management and for making progress in national farm sizes, has developed so far. Associations and co-operation have come to the fore instead; these bring about horizontal integration beyond the limits of the existing farms, thus modifying the size of the unit and the usual way of thinking in farm sizes, without increasing the actual size of any given farm. Nevertheless, this varies from county to county. (For example, as regards the state farms, in 1976 the average farm size was 2999 ha (max.: 5341 ha, min.: 1613 ha) in Heves county, and 11,346 ha (max.: 45,061 ha, min.: 2837 ha) in Hajdú-Bihar county.)

In the case of co-operative farms the average farm size was 6452 ha (max.: 1239 ha, min.: 914 ha) in Szolnok county, 2596 ha (max.: 7004 ha, min.: 521 ha) in Komárom county, and as small as 2551 ha (max.: 6963 ha, min.: 440 ha) in Szabolcs county.

All in all, it may be stated that we do not want to increase farm size to any considerable extent; no such measures are planned, nor will campaigns to this end be backed up.

The organization and strengthening of inter-farm associations and co-operations is, however, expected to increase. Steps are being taken to eliminate or reduce the present administrative and legal factors which hinder co-operations or cause a slash of interest. No co-operative or state farm is, however, urged to join an association just for the sake of being a member of one.

Thus, no rational farm size can be fixed definitely for all times since this question is always a function of the level of technical and economic development and the standard of management.

*

PÁL, GY.: *Today professional agriculturists are trained in the various faculties of three agricultural universities to undertake the direction of agricultural work in Hungary. Is there, in your opinion, an overproduction of agricultural professionals in Hungary, or will the overproduction only show up later, in which case it could be prevented now by reducing the number of students admitted to the universities ?*

ROMÁNY, P.: Owing to the concentration and rapid technical development of farms the demand by socialist large-scale farms for agricultural professionals has been variable over the last twenty years. In the future, manifold specific demands are to be expected. Thus, besides the three agricultural universities, a veterinary, a horticultural and a forestry engineering university, and three further colleges are also maintained.

The demands by large-scale farms for specialists are followed with constant attention, the specification of these demands is periodically supervised and the volume and direction of the training programmes are adjusted accordingly to suit the developing technologies and organization levels of the large farms. It is possible to create optimum correspondence between the demands and the educational programmes, and to avoid the overproduction of experts, which is, in any case always a relative concept.

In our opinion the socialist large-scale farms are at present adequately supplied with farm specialists. In the co-operative sector the reasonable demand is satisfied to some 80%, since there are problems with the distribution of trained personnel: in highly profitable large-scale farms near the cities there are signs that the number of experts is near saturation level, while in farms with unfavourable local conditions, situated far from the cities, a shortage of university and college graduates can be observed even in important posts. We wish to change this situation by various systems of state subsidization, which are expected to bring an improvement in the number of experts available in these areas. Allow me to mention here the peculiar difficulties encountered in trying to ease the problems of farms working under unfavourable conditions. Should we send young, newly graduated agriculturists, or experienced people with plenty of practical knowledge, who are sufficiently mature to manage a large-scale farm? The former may be discouraged by the difficult circumstances, the latter are already settled somewhere and are reluctant to change their place of work. But I do not wish to delve more deeply into the question.

As to the activities of higher education institutions: in some professions the number of students has been reduced. One of the results of this step is the availability of institutional capacity for the extension training of engineers, that is, possibilities are offered for training in special professions (computer techniques, economics, management, agricultural psychology, agricultural mathematics, etc.) for which the demand has arisen as a result of technical and organizational development. It is also good that we are able to receive an increasing number of foreign students.

It should also be mentioned that there is an increasing demand on the part of socialist large-scale farms for agricultural specialists; this is closely connected with the fact that a professional qualification has become the condition for occupying certain posts, specified by law. The number of jobs requiring university (college) education increases with the development of production conditions and technologies. In the concentrated large farms university (college) education is already indispensable not only for the director of the farm but also in some production management, technological and administrative posts.

Thus, there is no overproduction of agricultural professionals in Hungary at present, nor will there be in the future. The correspondence between the demand and the number of people trained can be maintained indefinitely in the framework of the socialist planned economy.

*

PÁL, GY.: *In 1949 61.6% of the population of Hungary lived in villages; by 1977 this proportion decreased to 49.3%. In 1949 76% of village earners worked in agriculture; in 1960 this number dropped to 42.2% and has been decreasing ever since. To what extent do you think* *the number of agricultural workers can be reduced without affecting the food supply of the country's population ?*

Romány, P.: This is, in fact, a complex problem.

— One of the questions is the ratio of urban to village population, as part of the process of urbanization. Between 1970 and 1975 the urban population increased by 6.7%, while the village population showed a 2.2% decrease (though many are living in the same place as before, but the village has been given town status). At the beginning of 1976 the proportion of the population living in towns was 50.4% while the proportion living in the 3100 villages was 49.6%.

— The other question is more difficult: of the 5.2 million people living in villages what percentage of the active earners (about 2.6 million) work in the different sectors of the national economy including agriculture. The proportion of agricultural earners living in villages is estimated to have decreased by now to below 40%.

As to the reduction in the number of those working in agriculture (irrespective of their place of residence), the situation is as follows:

1. Between 1970 and 1975 the number of those employed in agriculture decreased by some 150 thousand (20%), including a reduction of 89 thousand in the number of co-operative members.

2. According to data provided by the Central Statistical Office on the various sectors of the national economy in 1975 25.1% of the total number of workers were employed in agriculture, forestry and water management (it should be noted that in this system of registering the number of workers per sector, forestry is represented by 50 thousand and water management by 70 thousand workers).

Excluding forestry and water management, the proportion of agricultural ear ıers to the total number of earners was 19.9% at the beginning of 1976. The proportions naturally vary from county to county.

Attention should be drawn to the fact that the statistical data of developed capitalist countries, which are most frequently used for comparison, differ in many respects from ours as to their content. The comparison may, therefore, involve, many traps (if it is possible at all) unless the methodical differences are eliminated. For example:

— in Hungary the "total number of those employed" is generally used, and the proportions of earners are reckoned accordingly. In fact, however, of the 612 thousand people employed in co-operative farms in 1975 only 78.5% were active members. In many countries only the number of active earners are shown in the data, and those who work for only a few months of the year are also considered as employed;

— in foreign statistical data the number of so-called "service" workers is not included (they are represented in another sector). In Hungary everyone who works in an agricultural enterprise (who is employed there) is regarded as an agricultural worker, although nearly one-third of the total number of state farm workers are today employed in activities with no direct relation to agricultural production (e.g. in processing units, repair shops, transportation, trade and other branches).

This is why it is so important to examine first the content of the data!

The index of agricultural population density should be considered as much more important than figures expressing percentages. Oddly enough it is seldom used, although it is this index which really shows the technical level and intensity of agricultural production in a given country. At present, there are 6.7 ha agricultural area for each active agricultural earner in Hungary. To put it differently: in Hungary the area cultivated by one agricultural worker is larger than in many economically developed countries with a similar level of production. I think this index is very important, because we have to counter a deeply rooted belief that the smaller the percentage agricultural population the more developed the economy of the country. It is obvious that the figures quoted cannot be evaluated without considering the population density, the proportion of the country's area under agricultural cultivation or the structure and level of agricultural production in the given country. It is quite obvious that in a country with a high population density even a low percentage of agriculture may mean a better labour supply in agricultural production than a substantially higher percentage agricultural population in a sparsely populated country.

It may be assumed that in 1990, not including exports, each agricultural worker will produce sufficient food (or its raw material) for nearly 18 people. In 1970 the corresponding figure was 8, today it is about 11—12, based on the number of workers. This rate of growth would be higher if the production value to be attained via increased yields were taken as the basis.

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PÁL, GY.: *As Kautsky pointed out, the rise in food prices on the world market is not temporary but of a permanent nature; this he explained by the agricultural labour shortage and rising land rent. In your opinion, do the food prices in the Hungarian People's Republic show a rising tendency at present, and if so, what factors are responsible for this?*

ROMÁNY, P.: In answering the question I shall not start with Kautsky's statement, but shall deal first with the last part of the question and then return to the idea raised at the beginning, because this seems to be more logical.

Looking at the statistics on the changes in food prices during the fifteen years between 1960 and 1975, it can be stated that:

— food prices rose all over the world,

— within this fifteen-year period the rise in prices between 1971 and 1975, and particularly during the last two years of this period, accelerated,*

— in the socialist countries, excluding Yugoslavia, the price indices rose much more slowly than in the developed capitalist countries.

In Hungary the rise in food prices was 0.5% between 1961 and 1965, 1.1% between 1966 and 1970 and 2.7% in the period 1971—1975, on a five-year average.

For the sake of comparison it should be mentioned here that the growth rate for food prices in the Soviet Union was 0.8% between 1961 and 1965, and 0.2% in the period 1971—1975. In Austria, on the other hand, the rate was 4.6 and 6.4%, respectively, on the average for these two five-year periods; in Italy food prices rose by 4.7 and 11.5%, in Holland by 4.1 and 6.8%, and in the German Federal Republic by 2.3 and 5.4%, respectively, in the same periods. The rise in food prices between 1971 and 1975 was above 10% in several developed capitalist countries. In Hungary the slow rise in prices showed fluctuations in the fourth five-year plan period (1971—1975).

The rise in food prices was generally accompanied, both in Hungary and abroad, by a change in the consumption structure, an improvement in the quality of foodstuffs, and a rise in the processing level, which naturally also played a role in the tendency for food prices to rise.

We may now put the question: why are food prices increasing? Prior to explaining the slow rise in food prices in Hungary, I should like to shed some light on the component of the rise.

* Currently world market prices show a sharp drop for a number of products and an increase for others.

Apart from state subsidies, the current policy on living standards, and other factors, production costs always play an important role in food price trends. And agricultural production costs, the prime costs of major products and the costs of food processing show a tendency to rise.

In our developing agriculture, and also in other fields, the following factors go towards increasing production costs:

— energy costs, which are increasing as a consequence of the ever greater efforts required for energy production;

— the prices of materials and implements of industrial origin (machines, fertilizers, chemicals, etc.), which are increasing because of high industrial raw material costs;

— the rising proportion of materials and implements of industrial origin in the inputs required for agricultural production;

— the higher costs of unit working time;

— the cultivation of low productivity areas in order to satisfy the increasing food demand caused by the demographic explosion and the rise in effective demand;

— the exhaustion of the simple yield increase reserves even on good land, and the consequent need for considerable supplementary input;

— the increasing tendency towards capital intensity;

— the rising infrastructure and communal expenses (road construction, transport, water management, service and energy network), and investments to improve social provisions and living conditions;

— the improvement in quality, the higher degree of processing, and better methods of packaging.

The following factors contribute towards a reduction in production costs:

— the reduction in working time per unit product, that is, the higher productivity of manual labour;

— the biological achievements (high yielding varieties, energy-saving crops, etc.), and the sudden increase in yields generally;

— the proportional and complex character of development;

— the exploitation of soil potential (of course, this is not unlimited);

— the higher standard of organization, the development of production on a large-scale.

Out of these two groups of factors, those contributing to a rise in costs are the decisive ones. The production costs for some major products from co-operative farms showed the following trends in 1976 compared to 1971 (index: 1971 = 100):

wheat	124
sunflower	191
sugar-beet	148
onions	139
wine-grapes	123
apples	124
milk	143
feeder cattle	129
feeder pigs	118
broiler chickens	103

Each of these could be analyzed separately, but it will suffice to note that 1976 was a relatively poor crop year.

In the meantime food industry costs have also increased, so in fact the input required for food production has risen considerably in Hungary.

It must have been clear from what I prefaced my answer with that while the production costs in agriculture and the food industry have risen rapidly and substantially food prices have hardly changed.

The increase in agricultural production costs, like price rises of natural resources in general, is not followed by an increase in retail prices in the socialist countries, including Hungary. In Hungary retail price trends accord with the communist party policy on living standards and incomes. Owing to the basic importance of foodstuffs a decisive part of the retail prices are deliberately kept at a low level. It is thus understandable that production costs are constantly higher than retail prices. The government counterbalances this difference with various subsidies, in order to increase food production, develop the right structure, and improve the income and living conditions of the producers.

The periodical correction of retail prices is made in accordance with our policy on living standards, and helps to form consumption patterns favourable to the national economy and to keep a balance between supply and demand.

Unlike commodities with officially fixed prices, free-price produce (e.g. vegetables) show higher price fluctuations depending on crop results and trends in supply and demand: a sudden rise in the prices of imported consumer goods also contributed to the price increase between 1971 and 1975.

I do not think that the explanation for present food prices is to be found in Kautsky's argument, especialle, where the socialist countries are concerned. Kautsky examined the effects of an expanding capitalist agriculture, whereas what we are discussing now is a controlled farm policy, and its concomitant effects, implemented under socialist conditions, where the agricultural production is on the way towards industrialization.

In his work "Agrarian questions" (Die Agrarfrage, 1898) Karl Kautsky stated the fact that up to the second half of the 1870's food prices steadily rose, as opposed to industrial prices. The rise in prices exceeded that in wages. With reference to Kautsky it is also worth mentioning his observation that from the second half of the 1870's until the end of the century, food prices decreased due to the development of industry and the abolition of feudalism.

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PÁL, GY.: *In Hungary the price of a Rába-Steiger Tougar II type tractor is 1,394,000 Ft which is equal to the price of 4,725.42 q wheat. Taking 38.8 q/ha, the average yield in 1976, as the basis for calculations, this volume of wheat can be produced on 121.79 ha. Do you think that this ratio represents an unfavourable gap between the prices of agricultural and industrial products which may economically reduce the volume of production, or an increase in the efficiency of investments which will reduce production costs?*

ROMÁNY, P.: In Hungary the proportion of land, labour force and recycled produce of agricultural origin is decreasing while materials and facilities of industrial origin, together with various services, are assuming increasing importance within the total volume of inputs. Consequently, the level of agricultural production, the efficiency of investment, the specific costs, and thus retail prices are being determined more and more by the amount, price and efficiency of products from the machine, chemical, energy, building material industries, etc.

Besides production facilities of industrial origin and the machines and materials purchased abroad, the productivity of biological factors and its requirements in terms of energy, capital, etc., i.e. the utilization of biological potential, also plays a decisive role. The co-ordination of these two groups of factors (materials and facilities of industrial origin and biological components), and last but not least, well-organized, honest work, characterized by the increasing responsibility of the individual with a steady decrease in the number of those working in agriculture, combine to give the expected result and an answer to your question.

In Hungary agricultural production is gradually becoming industrialized; this is characterized by large farming units, the application of industrial principles of management and, as I mentioned earlier, by an increasing proportion of materials and facilities of industrial origin. Inasmuch as purchase prices on the domestic or foreign markets exceed the costs of the decreasing labour force, or if these prices result in a slower rate of increase in the value of output than in the price of input, agricultural production costs rise, as we have often witnessed lately.

In Hungary the price of a Rába-Steiger II tractor was, until recently, 1,394,000 Ft, which is equal to the price of 4,940 q wheat or 5,040 q maize. A similar tractor is equal in value to 2,670 q wheat or 3,145 q maize in Austria, and to 2,670 q wheat or 2,490 q maize in the German Federal Republic. (Here the price which the agricultural producer pays for the tractor is given, leaving out of consideration the state support granted to the manufacturers in order to moderate the high industrial prices.)

Having taken the above ratios into consideration- the price of the Rába-Steiger tractor was reduced to 1,194,600 Ft, whereby the ratios have naturally become more favourable.

In Hungary the purchase price of a combine is equal to the price of 2,400 q wheat or 2,630 q maize. In Austria the corresponding values are 2,100 q wheat or 2,370 q maize, and in the German Federal Republic 2,100 q wheat or 1,874 q maize. The costs of machine purchase are thus less favourable in Hungary by comparison.

Ratios calculated in a similar manner for the agricultural purchase prices of fertilizers, chemicals and feed concentrates are, due to state measures, somewhat more favourable in Hungary than in other countries.

In our experience, high capacity machines like the Rába-Steiger tractors are more productive and reduce the cost per unit of mechanical work, provided a full utilization of their capacity is made possible by adequate plot sizes, an appropriate supply of machines and careful work management. According to representative surveys made in co-operative farms, 14—17% cost reduction was attained in farms using one or two Rába-Steiger tractors.

In Hungary the purchase prices for machines are thus relatively high, but no far-reaching conclusions can be drawn from this about an unfavourable gap between the prices of agricultural and industrial products, or about any other phenomena, since not only are retail prices systematically regulated by the government, but changes in costs are also followed by changes in agricultural purchase prices, the credit policy and the state subsidies, whereby the government creates the necessary financial conditions for reproduction on an increasing scale. It is true that in the past intervention has often lagged behind events, instead of influencing and shaping the economic correlations in advance, but we hope to change this in the future. Today examples of the opposite tendency can already be found.

The industrialization of agricultural production is an objective process. Materials and chemicals of industrial origin, the various biological factors mentioned above, the proper equipment, and well trained human labour all greatly increase the efficiency of investment. The experience obtained so far shows that half-measures, rushed decisions, and "modernization" for the sake of modernization are extremely expensive factors. Therefore, in the course of development the capacity of the national economy is kept in mind when trying to satisfy the requirements of complex correlations. This is also done by the farms to an increasing extent, with costs and returns alike.

*

PÁL, GY.: *In order to supply the growing population with food, agriculture is compelled to turn out produce even at higher production costs; in socialist countries this surplus cost has to be borne by the national economy. Taking into consideration the present purchase prices of agricultural produce and the sum invested in agriculture, is there an accumulation or an export of capital in Hungarian agriculture?*

ROMÁNY, P.: It is already clear from what has gone before that food production can only develop in co-ordination with other branches of the national economy. This is also envisaged and ensured by our national economic plans. The development of individual branches is not carried out at random, but in accordance with our socio-economic objectives, at various rates and in different orders of magnitude, In other words: the extent of development planned in a branch while others are kept at the same level, develop moderately, or even reduce their activities is not a chance factor or something which is only discovered ex post facto.

To continue answering the question, I do not like to speak of the accumulation or export of capital in socialist agriculture. At most it is a question of which branches use the development funds produced in certain other branches of the national economy. Budget relationships are always distribution relationships too.

International experience proves that agricultural investments are increasing all over the world, both in developing and developed countries.

Investments (irrigation systems, roads, transport lines) require co-ordination even when they are in private ownership. Budget relationships have a great influence on development, though often very indirectly.

It is a well-known fact that half of the world population is starving. Hunger is not, of course, a product of our times; in 1069 Pope Urban II sent the crusaders off in the hope of acquiring land and putting an end to famine. The statistics have been recording regularly recurring famines ever since. Malthus derived his erroneous doctrines from the apparent contradictions between the growth rate of the world population and the food supply. The world is still concerned with the problems of abundance and shortage.

The agriculture of Hungary is known to be of basic importance not only is supplying the population of the country, but also by contributing to the development of the national economy through its active foreign trade balance. The export-import balance of agriculture and the food industry has increased by 54% in the rouble area and by 260% in the dollar area as compared to 1971. I should like to add that the proportion of imported material used in agriculture is low (about 9%), while in other branches it is two or three times higher. The positive balance of the per capita foreign trade in agricultural and food industrial products puts Hungary far ahead of many countries in the world.

*

PÁL, GY.: *Thank you for your information.*

Fig. 3. "Teopod" type mutant. The ramification and the comparatively well-developed glumes over the grains are suggestive of *Zea mays* tunicata, but in other features it is similar to cultivated maize

Fig. 4. "Corn-grass" type mutant. It has bushy growth habit with narrow grass-like leaves. It is characterized by short, sometimes bending, cluster-like male inflorescences and small female flowers from which 2—3 grains covered by glumes develop. There are types taller than the mutant seen in the picture, which have still narrower leaves

The spontaneous corn-grass mutation was discovered among the hybrids of sweet corn in 1941, and not much later, in 1950, was described by SINGLETON (1950, 1951, 1956) as a dominant mutation. Similar mutations were reported by LISIKOV *et al.* (1964), LISIKOV (1965, 1968, 1969) and KARAVCHENKO (1968), who described several variations of these types.

The "corn-grass" type plants differ from the teopod type mainly in the shape of the leaf. Their leaves are narrower, the stalks thinner, and the flower primordia very small. Under field conditions the plants have no panicle. These mutants often resemble the grasses, which is why they are called "corn-grass". A very rich selection of these mutant variations are available (Fig. 4).

Fig. 5. Chimera mutant. The main stalk has normal leaves and tassels. On the laterals the leaves are narrow and there are cluster-like male inflorescences at the apices

The next group contains the chimera mutants. In these plants there is a difference between the main stalk and the laterals. The main stalk is reminiscent of a normal maize stalk, while the laterals have narrow leaves, and sometimes a cluster-like male inflorescence; the stalk itself is also thinner. There are also types where only female flowers develop on the laterals (Fig. 5). In these mutants the cells have varying inheritance, consequently the corresponding organs within the same plant have developed in such a way that their tissues preserve various genetic relationships and are therefore different in many morphological features.

Fig. 6. Branching-type mutant. On the laterals cluster-like male inflorescences are found, and strong adventitious roots at the base
Fig. 7. Tubular formations occurring in mutants below the tassel

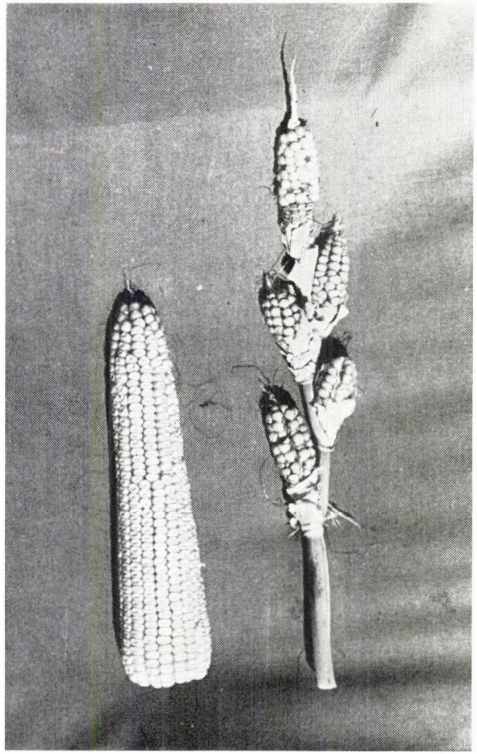

Fig. 8. Normal maize ear and mutant tube formation. On the right of the picture is a productive shoot from a mutant plant of generative character, situated at the apex. A short male inflorescence is seen at the end of each ear

Fig. 9. A mutant with a spadix suggestive of a spike. On the mutant shown in the picture the spadix has a cluster-like position on the flower axis where 4—5 ears develop

In the third group the branching-type mutants were placed, in which ramification occurs in the middle of the plant and not at the base (Fig. 6). In this group different variations are again found. There are laterals ending in tassels, but plants also occur with no tassels on the laterals, only cluster-like male inflorescences, at the base of which are 4—5 ears. The latter types may be of importance in producing higher yielding maize hybrids (Fig. 7).

Fig. 10. Unisexual female maize. If we succeed in finding or producing a pollinator which maintains the unisexuality and a male restorer, this type may play an extremely important role in hybrid seed production

A fourth group of mutants differs in the height of the plants and the width and position of the leaves. In this group there are dwarf and medium tall plants, narrow and broad-leaved ones, as well as plants with a sharp leaf angle, which may have a role in developing maize hybrids tolerant to stand density and mechanization.

The fifth group includes mutants in which the generative organs show morphological differences. Among them are pollen sterile types, plants of male character and some of definitely female character. As far as the position of the inflorescence is concerned, on some plants the cluster-like spadix is found immediately below the tassel, while on others it is in the middle of the plant (Fig. 8). Of the mutants belonging to this group, types with a cluster-like spadix are expected to be of great importance in developing high yielding maize hybrids. In these types the ears develop in a common stem part and are reminiscent of wheat spikes. Such a formation consists of 4—5 ears (Fig. 9). Besides these, however, there are normal multi-eared types as well. In some mutants the ears develop immediately above ground level.

Among the variations of our rich mutant population the so-called unisexual female maize type which has no tassel or any kind of male inflorescence is worth mentioning (Fig. 10). It will play an extremely important role in hybrid maize seed production. If pollinators are found which maintain female unisexuality or act as male restorers, the whole hybrid maize seed supply can be revolutionized. In addition to the above, many transitional type mutants are also available.

All this proves that with the proper utilization of the mutagens mentioned above a genetically diversified basic stock can be produced for breeding purposes, and this is one possible way of broadening the genetic basis.

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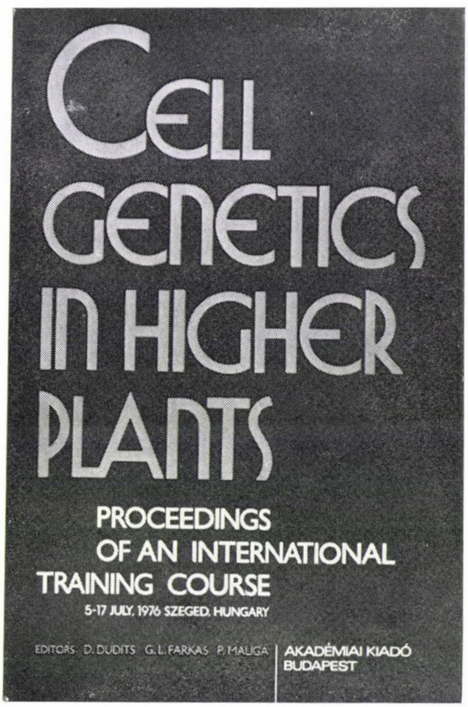


Dudits D.—Farkas G. L.—Maliga P.: *Cell Genetics in Higher Plants* (Proceedings of an International Training Course, 5—17 July 1976 Szeged, Hungary), Akadémiai Kiadó, Budapest.

This book is the publication of the International Course organized by the Biological Research Centre of the Hungarian Academy of Sciences (BRC) at Szeged on July 5—17th 1976 at the decision of the International Cell Research Organization (ICRO) and with the sponsorship of the United Nations Development Programme (UNDP) and the United Nations Educational, Scientific and Cultural Organization (UNESCO). It is divided into two main parts. The first part contains the lectures given by the international teaching staff, or abstracts thereof (pp. 3—218), while the second part summarizes the material of the practical training (pp. 221—251).

The first impression the reader feels when opening the book is one of disappointment because the table of contents makes it clear that the lectures delivered at the International Training Course cover only a minor field of the cell genetics of higher plants, discussing, in fact, the genetic questions of tissue (cell, tissue, protoplast, pollen) cultures, and the results and objectives attained, or expected to be attained, in genetic research on higher plants by using various methods of tissue culturing. On this basis "Tissue Culture Methods in Cell Genetics of Higher Plants" would have been a better title both for the training course and for the book. The inaccuracy of the title is unmistakeably confirmed by the first paper in the book, a short abstract of G. Melchers' introductory lecture "The present stage of plant cell genetics", from which it becomes obvious that the subject is treated only from the viewpoint of tissue cultures. It is a pity that the introductory lecture was not published in full.

In spite of the fact that the lectures are not grouped according to their subjects, they can be placed according to their character in five groups:

1. introduction (2 lectures)
2. mutation (2 lectures)
3. transformation (3 lectures)
4. protoplast culture (8 lectures)
5. organelle transfer (2 lectures)

Of the two introductory lectures that of Melchers has already been mentioned. The other, a lecture given by H. E. Street, under the title "Cell Cultures: a tool in plant biology", is an excellent comprehensive work that sums up and evaluates the most important results of the past decade, with special regard to callus and cell cultures, plant regeneration, cytological stability, freeze preservation, cell cycle and cytodifferentiation.

The second major group of problems is represented by the phenomenon of mutation; in this subject two lectures were held. In one of them: "Biochemical mutants in higher plants" by G. P. Rédei and G. Acedo, questions related with mutation induction and mutant isolation, auxotrophs, regulation of amino acid utilization, pyrimidine regulatory mutants and genetic control of flowering are discussed in detail. P. Maliga, in his lecture "Isolation of mutants from cultured plant cells", gives a full literary review of the resistant and auxotrophic cell lines reported in tissue culture, and deals in detail with the questions of mutant induction, isolation, maintenance, plant regeneration and inheritance.

The three lectures delivered in the third group were confined, in fact, to the general problems of plant genetic "transformation". In the lecture "Integration of exogenous DNA in plants: a hypothesis awaiting clear-cut demonstration", P. F. Lurquin tried to briefly review the literature in which claims in favour of or against specific effects of foreign DNA were made and to discuss some of the techniques that are or could be used in the study of exogenous DNA-uptake and fate in plant cells. In a lecture entitled "Has DNA corrected genetically thiaminless mutants of Arabidopsis?", G. P. Rédei and Gregoria Acedo give an answer to this question, saying: "we were unable to find any coincidence in favour of DNA-mediated correction in the material examined". F. Cannon briefly summarizes the results of physical studies of DNA-uptake by plant cells and studies on expression of procaryotic DNA in plant cells, and discusses the problems of bacterial transformation and plasmid construction in his lecture "The use of bacterial plasmids in plant cell genetics".

The fourth group of subjects in the book is connected with the theoretical, methodological and applicational questions of protoplast cultures. O. L. Gamborg, in his lecture entitled "Plant protoplast isolation, culture and fusion", deals with the subject in general, and sums up those species from which protoplasts were isolated and cultured to form dividing cells/plants; he presents the enzymes, solutions and conditions for protoplast isolation as well as the protoplast culture media. Subsequently, he discusses in detail the subjects of induced fusion and development of fusion products. The introductory lecture is followed by 6 papers discussing various aspects of this subject. I. Potrykus et al. were the first to give an account of intensive efforts to explore the conditions which induced sustained cellular division in cereal leaf protoplasts, under the title "Problems in culturing cereal protoplasts". Although about 80,000 variations in culture media compositions and in plant material have been tested, these conditions have not yet been found. E. C. Cocking, in his lecture "A new procedure for the selection of somatic hybrids in plants", has arrived, on the basis of his own research results, at the conclusion that "in utilizing natural differential sensitivities we have a generally applicable selection system". In a lecture entitled "Cytological studies on plant heterokaryocytes — Nuclear behavior", K. N. Kao briefly summarizes the most recent results concerning nuclei in subprotoplast, premitotic nuclear fusion and cell division in heterokaryons. The separation of heterokaryons from the initial cell populations and from various fusion products is one of the crucial problems of the fusion technique. In the lecture "The effect of selective conditions on the products of plant protoplast fusion", delivered by D. Dudits, various selective procedures such as complementation between recessive genes, auxin autotrophy, plant metabolites, enzymatic detoxification and temperature selection are discussed. A related question is dealt with by H. H. Smith in the paper "Characterization of somatic hybrid plants and further exploitation of a selective system", in which an account is given of the results obtained by using the *Nicotiana* tumor selection system and of possibilities for its utilization. The results of protoplast fusion carried out in flowering plants are well complemented by L. Ferenczy's studies in the *Aspergillus* species, and by his lecture "Some characteristics of intra- and interspecific protoplast fusion products of *Aspergillus nidulans* and *Aspergillus fumigatus*".

The fifth group of lectures held at the symposium is represented by two lectures on organelle transfer. In their lecture "Organelle transfer into isolated protoplast", which discusses the subject in full detail, I. Potrykus and H. Lörz touch on the problem of the uptake of microorganisms and try to summarize our present knowledge concerning uptake, integration, replication and expression of cell organelles, and also to point out some current problems and to indicate some future perspectives. The second lecture on the subject has the title "The use of subprotoplasts for organelle transplantation." According to R. Kollmann and H. Binding, "the subprotoplasts are the products of the fragmentation of a cell which frequently lacks at least one type of organelle". Some observations on subprotoplasts and their behaviour in fusion experiments are dealt with in their paper.

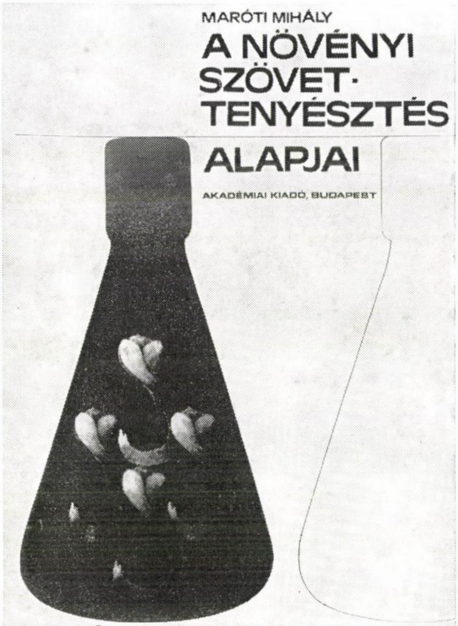
The possibilities and problems of utilizing protoplast cultures in plant virus research were summed up in the last lecture of the symposium: "Protoplasts: a new tool in plant virus research" by G. L. Farkas.

The second chapter of the book entitled "Practicals" gives a detailed and useful survey of the most important methods, such as:

pollen culture (C. Nitsch)
protoplast culture (H. Binding and J. I. Nagy)
protoplast fusion with polyethylene glycol (K. N. Kao)
uptake of nuclei into protoplasts (H. Lörz and I. Potrykus)
uptake of a bacterial plasmid by cells (F. Cannon and P. Lurquin)

All in all, the book "Cell Genetics in Higher Plants" gives an excellent summarization of tissue culture investigations connected with the cell genetics of higher plants. It discusses in detail the latest results and problems of plant cell genetics. The prominent international teaching staff hallmarks the lectures and the book. It has the advantage of giving a detailed description of the most important methods, besides the discussion of theoretical questions. Accordingly, the book efficiently complements the works recently published in this field and adds to the success and fruitfulness of the international training course organized at the Biological Research Centre of the Hungarian Academy of Sciences, Szeged. The rich material of the book offers substantial help in basic and applied research on plant cell genetics and tissue cultures thereby promoting the further development of this field of plant biology.

L. Heszky



MARÓTI M.: *A növényi szövettenyésztés alapjai* (Tissue cultures of plants). Akadémiai Kiadó, Budapest, 1976. 345 p.

The book presents the methodology of protoplast, cell, tissue, organ and embryo cultures and the results of investigations in connection with two decades of experimental work carried out by the author. The 345-page work, written in Hungarian, contains 82 black-and-white and 32 colour plates, and a bibliography divided into chapters.

After the introduction, which deals with the problems of cell biology and the physiology of plant organization, the author gives a survey, in six chapters, of the interaction between the metabolism and biofactors influencing differentiation, with a critical evaluation.

The chapter "Cultures of isolated plant parts" discusses the utilization of sterile and isolated organ cultures in studying the correlations of plant organization. The action mechanism of hormone treatment and the effectivity of interrelations can be separated from the metabolic processes only under controlled conditions, so results can only be considered exact and verified when obtained by such methods. The historical review of organ cultures confirms this view.

In the chapter "Metabolism of isolated plant parts" the importance of the inorganic (macro- and microelements) and organic (nitrogen and carbon sources, vitamins, etc.) composition of culture media is dealt with in the form of a comprehensive review of cultures, which, in fact, serves as a theoretical basis for choosing the actual culture medium. Besides heterotrophic carbon assimilation, the possibilities of photosynthetic carbon dioxide fixation in isolated cultures are also considered in connection with chlorophyll formation. The organizational basis of autotrophic carbon metabolism (photosynthesis) is chlorophyll formation, as well as regular chloroplast development, and illumination comes into effect as an external condition. Photosynthesis is also influenced by many endogenous factors; the stimulatory effects of cytokinins are particularly well-known. The chlorophyll content of isolated cultures is generally a fraction of that found in intact plant organs. The intensity of the Hill reaction, on the other hand, increases with the rise in the atmospheric carbon dioxide level (2%), while there is a simultaneous decrease in cell respiration. In isolated organ cultures the photosynthetic carbon dioxide fixation is correlated with the protein content and with the intensity of nitrogen assimilation. In plant organ cultures nitrate has recently been added to the free-amino acid mixtures; this decreases the deamination. The metabolism of isolated organs is regulated by a hormone interrelation, based primarily on the action mechanisms of auxin, gibberellin and cytokinin. Research results concerning factors acting on the regulation of callus induction and auxin synthesis are discussed by the author in full detail. On the subject of gibberellin and cytokinin interaction the influence exerted on nucleic acid synthesis is dealt with in full; this is very important from a theoretical point of view, though the author's conclusions are always moderate. Especially, important are the studies on the action mechanism of exogenous factors in isolated organs, which specifically inhibit or stimulate growth and metabolism with respect to hormone interrelation.

The chapter "Growth, differentiation and organogenesis of isolated plant parts" considers the organization processes of organ, callus and cell cultures in relation to each other. The culturing of isolated embryo and seed primordia is a modern and well-proven method in genetics and plant breeding, which the author compares to the development processes of protoplast cultures, regenerated embryoids and reorganized zygotes. The organ cultures (root, shoot, leaf and flower) provide test material for many theoretical questions of plant evolution (biosynthesis, hormone interrelation, etc.), and in addition supply results which can be used in the production of elite propagation stock for virus-free (reduced virus content) cultivated plants (fruit trees, ornamental plants, etc.). Today organ cultures are used in relatively large quantities by horticulturalists to reduce viruses. Particular emphasis is laid in this chapter on research results obtained with anther and pollen cultures, where in anthers isolated at the premeiotic stage, meiosis and microsporogenesis took place normally under the influence of special biofactors. Literary data concerning callus cultures are discussed by the author in connection with many experimental results, many of them his own. Besides the detailed description of technical procedures, the presentation of the different types of organ induction and the related metabolic-physiological changes is highly valuable. Many original data are presented on the hormonal regulation of plant organ formation, too. The most efficient method of cell culturing is to prepare cell suspensions in special cultures. In shaken cultures the isolated cells remain isolated, or show a special differentiation, the methodology and results of which are presented in connection with the author's own experimental data. The organization and embryogenesis of somatic diploid cells are demonstrated by means of accessory embryo formation starting from a single isolated cell. After the development of proliferation points, accessory embryogenesis often reaches the torpedo stage, according to the experimental results presented. The author gives examples of full plants organized from embryogenic cells as well. A whole plant may also develop from the pollen (microspore) by induction, but this will be haploid. Some cases of the latter have already been published, but the author also discusses his own experimental results in detail. The original experimental results are of special importance because the test was performed with carrot *(Daucus carota)* and does not thus refer to the Solanaceae genera like the earlier data. Besides the methodology of preparing plant protoplast cultures, the mechanism of protoplast fusion is also described, which makes the chapter very up-to-date. The growth, division, fusion, histo- and morphogenesis of protoplast cultures are described up to the development of the whole plant. New vistas have been opened up for phytogenetic research into protoplast hybridization (homocaryotic and heterocaryotic cell hybrids), which are of great importance not only from a theoretical point of view, but also because they represent a new tendency in practice, due to their implications in plant breeding. The methods of somatic (intra- and interspecific) hybrid production, and the evolutionary and genetic characterization of the hybrids are also discussed; these are not only new from a genetic point of view, but are also suitable for inducing transformation, progressive mutation and modification through partial genome introduction. Beyond this, protoplast cultures can be used to analyze the mechanism of plant virus infections and the biochemistry of virus propagation.

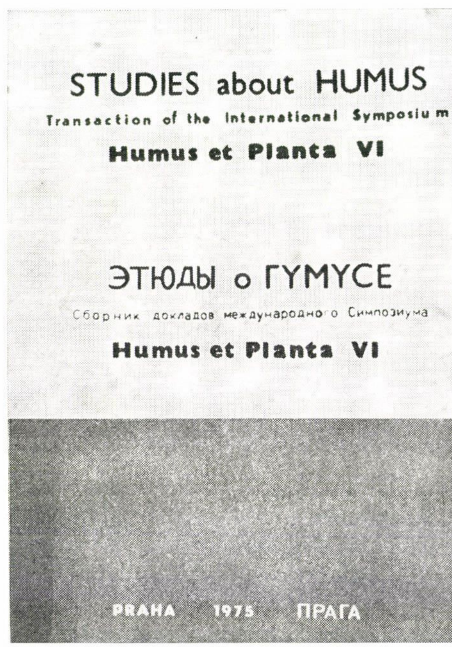
The chapter "Tumorous tissue cultures" summarizes the results attained in investigations into the organization characteristics of tumours induced by bacteria and by viruses, those of genetic origin and those of unknown character. Habituated tumours (which divide and grow independently of auxin) are dealt with in full detail in connection with the interplay of endogenous biofactors. The tissue growth induced by factors which play a part in tumour induction is not of a self-regulating nature. The characteristic difference between the organic matter levels in tumorous tissues and normal tissues provides information on the pathological metabolism, and investigations have been focussed on the reversibility of metabolic reorientation. Data are presented on somatic cell hybrids in which a tumour of genetic origin has formed. The analysis of the induction of a genetic tumour is an important contribution to the comparison of tumours induced by non-oncogenic factors.

The chapter "Fields of application of plant cultures" summarizes the possibilities of direct and indirect practical utilization. The synthesis of a number of pharmaceutical and chemical basic materials under controlled conditions is planned on the basis of the results of earlier successful pilot experiments. For example, of the alkaloids, atropine, *(Atropa belladonna)*, nicotine *(Nicotiana tabacum)*, hioscine *(Datura stramonium)*, etc.; of the glycosides, scopoline and scopoletine *(Nicotiana tabacum)*, the steroid glycosides (cortisone precursor hecogenine) *(Agave toumeyana)*, digitoxigenine *(Digitalis purpurea)*, etc., which are some of the most important basic materials, have already been economically extracted using industrial fermentation techniques. The production of volatile oils, terpenes and flavonoids, etc. through tissue cultures has also been solved. The mericlone reproduction of plants (development of clones through meristemic tissue cultures) is aimed partly at producing a virus-free elite propagation stock on a farm-scale, and partly at providing a method suitable for widening the range of varieties in the breeding of valuable ornamental plants (e.g. orchids). The author describes in detail the methodology of mericlone reproduction in orchid cultivation.

The chapter dealing with "General technical problems of isolated culturing" contains the methodology and implements required for organ, tissue and cell culturing, the types of sterilization and the composition of culture media in sufficient detail to be of practical use.

The author presents a highly competent account of the experimental results of the new technology and trend in plant cell biology and the metabolism on which they are based. The work is very thorough and is supplied with a full range of the relevant literature.

B. I. Pozsár



Studies about humus. Transactions of the International Symposium, Humus et Planta VI. (Edited by B. Novák, J. Pokorná-Konová, F. Kunc, J. Kubát, J. Damaska) Prague 1975. 489.

This 489-page publication in English and Russian contains the material of 86 lectures delivered at the Symposium "Humus et Planta VI" held in Prague between 18th and 22nd August 1975.

The conference was organized by the Research Institute of Plant Production, Prague-Ruzyne, with the assistance of the

Faculty of Agronomy, Agricultural University of Prague and the Czechoslovak Society for Agricultural, Sylvicultural and Food Sciences of the Czechoslovak Academy of Sciences, Department of Soil Sciences.

The editors have dedicated the publication to Prof. PhDr. Silvester Prát DrSc., member of the Czechoslovak Academy of Sciences, founder of the Prague Symposia on "Humus et Planta".

The introductory report by Mr. Bohumir Novák, Chairman of the conference, gives a 9-point survey of Czechoslovak humus research and calls attention to the fact that the problems dealt with in the papers included in the publication compose the subject of research in other developed agricultural countries as well. These subjects are:

1. the bulk of bound plant nutrients
2. the adsorption capacity
3. substrate for soil organisms, esp. soil microorganisms
4. capability to form the soil structure elements
5. chelating of heavy metals
6. appropriate rate of mineralization
7. temporary immobilization of plant nutrients, esp. nitrogen
8. ability to detoxicate the biocide residues
9. stimulating effects on the plant growth.

If we wish to follow the historical development of humus research and the fields of research during the past 3—4 decades interesting observations can be made by surveying the subjects of the papers and the number of lectures delivered on the different subjects. In the first place, it can be established that interest in the direct relationship between humus and plant nutrition has decreased. This is not, in fact, surprising. With the high rate of fertilization applied in agriculture today the nutrient-supplying role of humus has ceased to be of a decisive character. At the same time, interest in the role of humus as a nutrient carrier, especially of microelements, has increased. The reason for this seems to be an increased interest in microelements rather than in humus research. The organomineral components of the soil, particularly microelements and the chelate-type complexes in the humus, are at the centre of scientific interest. Works by M. Andrzejewski—Rosikiewicz; Sapek; S. Krystanov—E. Filcheva; N. A. Vlasov—A. I. Mikhaylova; F. D. Ovcharenko et al. and W. Rochus deal with these questions.

The development of biochemical separation techniques and methods of chemical structural analysis also makes its effect felt in humus chemistry.

In this range of subjects we find papers on extraction and purification techniques (P. Sequi et al.; I. S. Stepanov; O. H. Danneberg; Lakatos et al.). The heterogeneity of organic matter in the soil, the fractionation of the organic matter and the physicochemical characterization of the fractions are dealt with by many authors. The most diversified forms of chromatographic and electrophoretic techniques have been used in fractionating humous substances, as may be seen from the works of M. Valla; L. Pavel; G. Cacco et al.; J. Witthauer; G. Guidi et al. The elementary composition of humous substances, their physicochemical properties and the spectroscopic examination of their structures are discussed in a number of works. The microelementary analyses and DTA examinations of G. Giovanni et al. and the pyrolysis-gas-chromatographic studies of F. Martin and C. Saiz-Jiménez are especially interesting. The results of DTA examinations are also presented by P. Jambu and T. Dupuis. P. Sklodovski publishes the results of infrared spectrophotometry. H. Lenz compares Raman spectra with IR spectra, and presents the results of structural examinations carried out by PNMR spectrometry, NMR spectrometry and X-ray diffraction. B. M. Kress discusses the relationship between the phosphorescence of humous substances and their chemical structure.

Modelling the formation of the humus complex by chemical and microbiological methods, is the subject of the next group of papers published in the book. The authors are: W. Sievert; M. Kononova; L. V. Aleksandrova; N. N. Zhdanova et al.; F. Gulyás; J. Szegi; I. D. Dzumaniyazov. A large number of papers dealing with the humification of various substrates, including their conditions, microbiology and enzymological processes, also belong essentially to this range of subjects. Such are the works of N. N. Zhdanova et al.; F. Gulyás—J. Szegi; B. Novák; I. D. Dzumaniyazov; Wójcik et al.; J. Pokorná-Konová; J. P. E. Anderson; J. K. Domsch; A. Dubovská et al.; K. Soidra; S. H. A. Chulakov; T. G. Zimenko; J. Nováková; F. Kunc; V. Cizek; Th. Weichelt; Bönischová—Franklová; M. Tesarová —J. Gloser; P. G. Arcara—C. Piovanelli; J. Kubát—B. Novák; W. Ziechmann et al.; S. Cervelli et al.; T. A. Shcherbakova—N. A. Galushko; P. Nannipieri et al. and N. C. Panikov et al.

Papers on humus research of an agronomical character, or related with plant nutrition, or discussing the influence of other agrotechnical factors, were presented by G. Müller—W. Heisig; J. de Leval; R. Apfelthaler; A. Putikován—B. Novák; V. N. Prokoshev; I. Hargitai et al.; E. M. Varju; K. V. Dyakonova; V. A. Semenov et al.; F. Löbl et al.; L. Pryczkova; M. Niklewski et al.; S. Guminski—J. Sulej; V. L. Stanchev et al.; V. Tichy—Hoang Kim Phuong; G. Petruzzelli et al.; G. Dell'Agnola—G. Ferrari; V. A. Semenov; V. Vancura; Th. Beck; S. Sotáková—V. Mucha and A. N. Nebolsin—Z. P. Nebolsina.

The nine lectures that deal with the humus research aspects of soil genetics present humus formations and phenomena related with these formations in connection with the climatic and geological conditions. The authors of these works are: F. Jacqouin et al.; F. Lemaire; T. Dupuits et al.; L. Manuseva—O. Stojanovic; B. Grunda; B. Ulehlová et al.; E. G. Vuchrer et al.; G. P. Petrosyan et al. and M. P. Aranbaev—E. V. Aranbaeva.

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